Impacts of Technology

A Standards-Based High School Model Course Guide

Grades 9-12

"Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world."

Albert Einstein

Advancing Technological Literacy: ITEA Professional Series
Contemporary Curriculum for Technological Literacy

ITEA-CATTS Consortium

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Preface

To invent, you need a good imagination and a pile of junk.
Thomas Edison

If *imagination* is the ability to visualize new and creative concepts and *engineering* is the practical application of knowledge...then *imagineering* can be defined as the ability to create, innovate, and apply information to solve problems. A description for a course catalog might read:

> Impacts of Technology – Take all of the information you have learned in school so far and put it to use along with your imagination. This course will give students the chance to dream up new ideas and make them come true by building them using technology. Students will learn to collect, analyze, and use information to figure out the best uses of technology.

Impacts of Technology gives students a look at the "big picture" of education...a way to use all of the information they have been studying while wondering about why it was so important. It is difficult to imagine an occupation outside of education where a person would use science concepts only from 8:00 to 9:00, perform math calculations from 9:00 to 10:00, and write from 10:00 to 11:00. Many high school students have been conditioned to the workings of the schools, and most are unprepared for the real world of work. Additionally, the practical application of all of the subjects a student has taken in elementary, middle, and high school provides a glimpse of a variety of occupations that students might pursue, Figure 1.

Accountants
Advanced Technology Researchers
Architects
Architectural Designers
Audio/Video Specialists and Engineers
CAD Specialists
Carpenters
Civil Engineers
Colorists
Computer Software Designers and Programmers
Conceptual Designers
Construction Managers
Contract Administrators
Cost Engineers
Electrical Engineers
Electronic and Electromechanical Assemblers
Environmental Designers and Space Planners
Exhibit Designers
Facility Designers and Space Planners
Financial Analysts
General Services Support
Graphic Designers
Human Resource Specialists
Illustrators
Industrial Designers
Industrial Engineers
Interior Designers
Landscape Architects
Librarians and Information Specialists
Lighting Designers
Local Area Network Administrators
Machinists
Materials Applications Designers
Material Planners
Mechanical Engineers
Model Builders
Optics and Projection Systems Engineers
Plastics Fabricators
Producers
Production Artists
Production Coordinators
Project Estimators
Project Managers
Project Planners
Project Schedulers
Prototype Developers
Quality Assurance Engineers
Scenic Artists
Screen Printers
Sculptors
Secretaries
Show Technology Designers
Show Set Designers
Special Effects Designers
Story and Copy Writers
Storyboard and Sketch Artists
Strategic Planners
Systems Engineers
Telecommunications Specialists
Tool and Die Makers

Figure 1: A partial list of the various occupations that make up Disney's Imagineering team.

As a teacher, offering a class called Impacts of Technology to students can be challenging and rewarding. The challenges include being able to facilitate the variety of student ideas and steer their enthusiasm toward the appropriate resources. The rewards come in the form of students dreaming up ideas that you would never have thought of yourself, and the feeling of pride in providing an environment where students have used their knowledge and talents to solve a difficult problem.

As a student, Impacts of Technology can be the first school experience where the “Big Picture” comes into focus. Why did you have to learn to communicate through reading and writing? Where will you ever use all that math? When will you ever need to use the science facts you studied? Impacts of Technology can put all that information to use in the design and construction of things you have only dreamed of in the past.

Course Length:	12, 18, or 36 weeks
Suggested Grade Levels:	7-12
Suggested Prerequisite:	Foundations of Technology

About of This Guide

This guide presents a model for a standards-based contemporary technology education course for the high school level. This model course guide features an exploratory curriculum thrust for a cornerstone high school level course. Course content is based on International Technology Education Association (ITEA) Technology for All Americans Project publications, *Rationale and Structure for the Study of Technology* (ITEA, 1996), *Standards for Technological Literacy: Content for the Study of Technology (Standards for Technological Literacy/STL)* (ITEA, 2000, 2002) and *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards* (*AETL*) (ITEA, 2003). Also, if your state has standards for technology education, it will be important to correlate those standards with the standards for technological literacy.

Rationale & Structure for the Study of Technology

Rationale and Structure for the Study of Technology provides a vision for the study of technology. It addresses the power and promise of technology and the need for every American student to be technologically literate when he/she graduates from high school. Understanding the nature of technological advances and processes and participating in society’s decisions on technological issues is of utmost concern. This publication outlines the knowledge, processes, and contexts for the study of technology.

Standards for Technological Literacy: Content for the Study of Technology

What is *Standards for Technological Literacy*?
ITEA and TfAAP published *Standards for Technological Literacy: Content for the Study of Technology (STL)* in April of 2000. *STL* defines, through K-12 content standards, what students should know and be able to do in order to be deemed technologically literate. However, it does not put forth a curriculum to achieve these outcomes. *STL* will help ensure that all students receive an effective education about technology by setting forth a consistent content for the study of technology.

Why is *STL* important?

- Technological literacy enables people to develop knowledge and abilities about human innovation in action.
- *STL* establishes requirements for technological literacy for all students from kindergarten through grade 12.
- *STL* provides expectations of academic excellence for all students.
- Effective democracy depends on all citizens participating in the decision-making process; many decisions involve technological issues, so citizens need to be technologically literate.
- A technologically literate population can help our nation maintain and sustain economic progress.

Guiding Principles for *STL*

The standards and benchmarks were created with the following guiding principles:

- They offer a common set of expectations for what students should learn about technology.
- They are developmentally appropriate for students.
- They provide a basis for developing meaningful, relevant, and articulated curricula at the local, state, and provincial levels.
- They promote content connections with other fields of study in Grades K-12.
- They encourage active and experiential learning.

Who is a technologically literate person?

A person who understands—with increasing sophistication—what technology is, how it is created, how it shapes society, and in turn, how technology is shaped by society, is technologically literate. A technologically literate person can hear a story about technology on television or read it in the newspaper and evaluate its information intelligently, put that information in context, and form an opinion based on it. A technologically literate person is comfortable with and objective about the use of technology—neither scared of it nor infatuated with it.

Technological literacy is important to all students in order for them to understand why technology and its use is such an important force in our economy. Anyone can benefit by being familiar with it. All people, from corporate executives to teachers to farmers to homemakers, will be able to perform their jobs better if they are technologically literate. Technological literacy benefits students who will choose technological careers—future engineers, aspiring architects, and students from many other fields. Students have a head start on their future with an education in technology.

What is included in *STL*?

There are 20 content standards that specify what every student should know and be able to do in order to be technologically literate. The benchmarks that follow each of the broadly stated standards at each grade level articulate the knowledge and abilities that will enable students to meet the respective standard. A summary of the content standards is presented on page x of this document. Teachers are encouraged to obtain *STL* to review the benchmarks associated with each standard.

Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards (AETL).

While the *Rationale and Structure for the Study of Technology* provides a vision and *Standards for Technological Literacy: Content for the Study of Technology* provides the content, neither was designed to address other important elements that are critical to a comprehensive program of technological studies. As a result, ITEA's TfAAP published *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards (AETL)*. *AETL* was disseminated at the ITEA Annual Conference in March 2003 and is currently available from ITEA. This publication will help schools to implement new strategies and evaluate existing practices of assessing students for technological literacy, providing professional development for teachers and other professionals, and improving programs of teaching and learning.

ITEA-CATTS Professional Publication Series

The ITEA-CATTS Consortium has also produced standards-based documents that should be consulted. *Teaching Technology: High School* (ITEA, 2001) is one of these guides. This course model incorporates contemporary methods and strategies recommended in the latter publication. Methods and activities are intended to support the learning of what is important to know and be able to do in the study of technology. Teachers, department chairpersons, and supervisors are encouraged to review these publications prior to using this guide in order to understand the foundations and research-based content upon which this publication is based.

International Technology Education Association – Center to Advance the Teaching of Technology and Science

(ITEA-CATTS) was created in July 1998 to provide curriculum and professional development support for technology teachers and other professionals interested in technological literacy. ITEA-CATTS initiatives are directed toward four important goals:

- Development of standards-based curricula.
- Teacher enhancement.
- Research on teaching and learning.
- Curriculum implementation and diffusion.

The Center addresses these goals to fulfill its mission to serve as a central source for quality professional development support for the teaching and learning of technology and science. Teachers, local, state, or provincial supervisors, and teacher educators are encouraged to become familiar with ITEA-CATTS and how this Center will provide additional support as *STL* is implemented.

ITEA-CATTS Consortium was established as part of ITEA-CATTS to form professional alliances in order to enhance teaching and learning about technology and science. Consortium members receive quality curriculum products and professional development based on the standards. This publication was conceptualized and developed through the Consortium.

Using This Guide

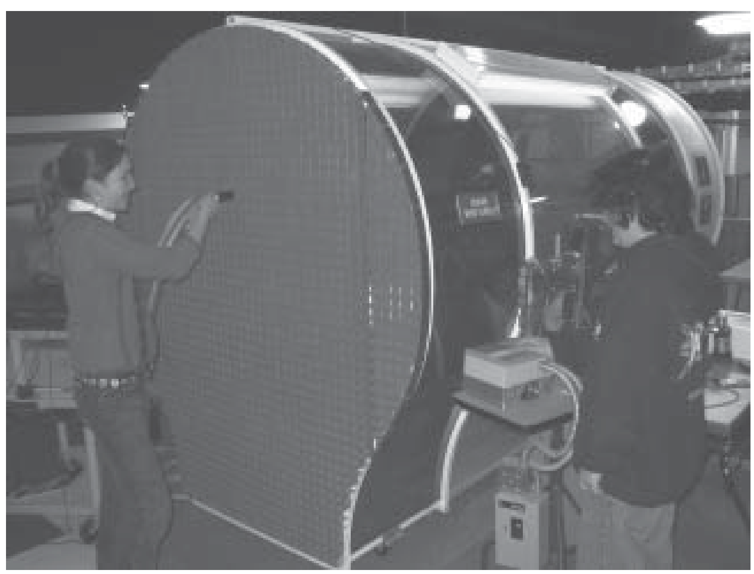
Assessing Technology

Technology is neither good nor bad. The appropriate application of technology is a concept that can be hard to teach without expressing personal bias or individual values. The contents of this guide will help teachers and students to develop the ability to analyze technology and its impact on the environment and society. Technology assessment as a stand-alone curriculum might be interesting to some students, but given an opportunity to design and build projects while considering their technological impact has a broader appeal.

Applying Technology

This guide presents a series of activities and ideas that have captivated both middle school and high school level students. While some teachers may choose to duplicate the same projects, the intent of this guide is to offer a format in which students can express their imaginations in the design and problem-solving endeavors that they find most interesting. Teachers are often equally as enthusiastic about the student-driven projects and find a renewed love of learning.

Look through this guide with an open mind and try to imagine how your education might have been different if you had an opportunity to take a class called *Impacts of Technology*.



Students test an R/C airplane in a large wind tunnel built in an Impacts of Technology class. A non-toxic smoke generator provides a means to see the movement of air over the control surfaces while a digital frequency controller adjusts wind speed.

Introduction to Impacts of Technology

Introduction to Impacts of Technology

Imagination + Engineering = Creative Design

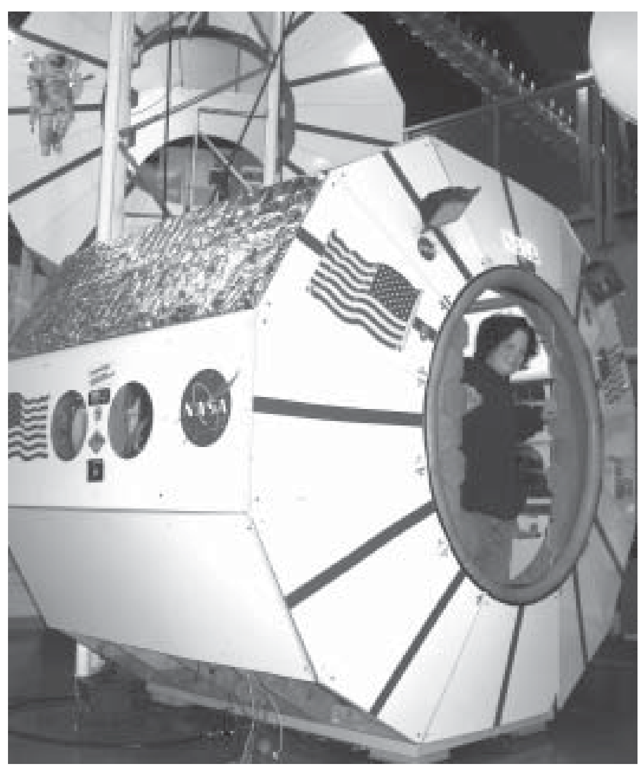
Using one's imagination is a skill that comes with practice. From early elementary through middle school, being imaginative is often encouraged through various cooperative and hands-on activities. All too often, however, students find that many high school courses place less emphasis on encouraging imagination and more on prescribed learning, often in preparation for those all-important standardized tests. This model course guide is designed to prepare technology education teachers for teaching a class that can give students an opportunity to apply their imagination by engineering specific solutions to problems.

Considering the fact that the vast majority of graduate engineering students in United States universities are not U.S. citizens, there is no better time to introduce high school age students to the field through creative design experiences.

Correction

Imagination + *Technology Assessment* + Engineering = Creative Design with Consideration of Technological Impacts

In addition, Impacts of Technology students learn that *technology* is a neutral topic that can have good or bad impacts on society. This *Technology Assessment* component of Impacts of Technology is not to be confused with assessing students. Rather, it is a structured evaluation of the application of technology in an effort to avoid inappropriate and unwanted effects. Applying imagination without considering the possible effects of new products or processes can lead to technological disasters, superfund sites, and unsafe products that could have been avoided in the initial design phases. Whether a new product, system, or process has an overall positive, neutral, or negative impact depends on the proper understanding of technology assessment. This aspect of Impacts of Technology will give students a head start on the road to technological literacy. Technology assessment is an important component of Impacts of Technology, but *Imagintechassesineering* is not a catchy name.



This student-designed and -built space station project floats on air bearings to simulate a docking procedure.

Lab Activity	Chapter	Imagineering
Brainstorming	4	IDEA
Problem Solving	2	PRACTICAL REASONING
Sketching, CAD	4-2	INITIAL DESIGN
Synthesizing Data	3	PHASE 1 - TECHNOLOGY ASSESSMENT
Project Management	2	PROROTYPE CONSTRUCTION
Sketching, CAD	1,4	RE-DESIGN
Synthesizing Data	3	PHAZE 2 - TECHNOLOGY ASSESSMENT
Sketching, CAD	4	FINAL DESIGN
Materials & Processes	*	CONSTRUCTION
Data Collection	1	TESTING
Materials & Processes	1	MODIFICATION
Continuing Classes	4	FUTURE MODIFICATION

**Assumed Knowledge*

What Do You Do in Impacts of Technology?

This guide will provide teachers with background and specific examples of what can happen in a class called Impacts of Technology. Teachers should note that the class requires students to do more than design new products. Additionally, students are expected to learn systematic practical reasoning, and develop an understanding of technology assessment.

Impacts of Technology is a class that allows students to apply their imagination toward the designing, problem-solving, and building of projects that are most interesting and timely.

Impacts of Technology provides students with opportunities to apply their imaginations while using engineering skills…a class that all students appreciate because they are more in control of their individual learning process. Think of how your educational experiences might have been enhanced in a class where your dream of a space station that floats on a cushion of air can come true.

Chapter 1

Applying Technology Standards Through Impacts of Technology

Chapter 1

Applying Technology Standards Through Impacts of Technology

"Engineers are the professionals who are most closely associated with technology."
Standards for Technological Literacy: Content for the Study of Technology

Impacts of Technology closely parallels *Standards for Technological Literacy: Content for the Study of Technology*. The first of five categories outlined in the standards deal with the nature of technology. Specifically, those standards include the following:

The Nature of Technology

- Students will develop an understanding of the characteristics and scope of technology.
- Students will develop an understanding of the core concepts of technology.
- Students will develop an understanding of the relationships among technologies and the connections between technology and other fields.

Additionally, teachers are encouraged to investigate and apply the other four categories of technology standards. Technology assessment is most closely associated with the content standard entitled Technology and Society.

Technology and Society

- Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- Students will develop an understanding of the effects of technology on the environment.
- Students will develop an understanding of the role of society in the development and use of technology.
- Students will develop an understanding of the influence of technology on history.

Impacts of Technology applies the design content through student-driven projects. Using practical reasoning skills, students learn to follow a systematic approach to solving problems. Designs are often created through cooperative group interaction. Students learn to communicate ideas verbally, through writing, and most commonly, using sketches and drawings.

Design

- Students will develop an understanding of the attributes of design.
- Students will develop an understanding of engineering design.
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- Students will develop the abilities to apply the design process.
- Students will develop the abilities to use and maintain technological products and services.
- Students will develop the abilities to assess the impact of products and systems.

The Designed World

- Students will develop an understanding of and be able to select and use medical technologies.
- Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.
- Students will develop an understanding of and be able to select and use energy and power technologies.
- Students will develop an understanding of and be able to select and use information and communication technologies.
- Students will develop an understanding of and be able to select and use transportation technologies.
- Students will develop an understanding of and be able to select and use manufacturing technologies.
- Students will develop an understanding of and be able to select and use construction technologies.

This chapter addresses the nature of technology in Impacts of Technology. Technological literacy requires the ability to understand the role that technology plays in areas such as the following:

- Natural vs. synthetic material applications
- Using tools
- Creativity, logic, and innovation in the design process
- Solving problems
- Product development
- Exponential growth of technology
- Systems, processes, trade-offs, and control of technology
- Properties of materials
- Product or process specifications, management, and control

This model course guide will describe classroom management techniques and provide specific examples of activities in Impacts of Technology. While some activities are very specific and detailed, others are discussed in more general terms to give ideas to teachers and students. Creative design topics are outlined and ideas are offered for teachers to follow as a starting point in this exciting course of study. The process of designing, where teachers and students find satisfaction in the application of research, is an individual experience that is rewarding in itself. Many of the activities described in this guide do not include detailed drawings and dimensions as that is the realm of individual student design and problem solving.

This student has successfully completed a design challenge to create a remote-controlled, lighter-than-air vehicle.

Review the Nature of Technology

Impacts of Technology applies *Standards for Technological Literacy: Content for the Study of Technology* through hands-on and minds-on application. The category outlined in the standards document deals with the Nature of Technology. Specifically, those standards include the following:

- The characteristics and scope of technology
- The core concepts of technology
- The relationships among technologies and the connections between technology and other fields

Impacts of Technology is not typically an introductory technology education course. This course is designed to give students an opportunity to apply their ideas using the skills and understanding learned in previous technology classes. Ideally, students would have the opportunity to explore a wide variety of technology concepts, starting in an elementary program. Depending on when a student can start learning about technology, Impacts of Technology could be offered either in middle school or, more likely, in a high school setting.

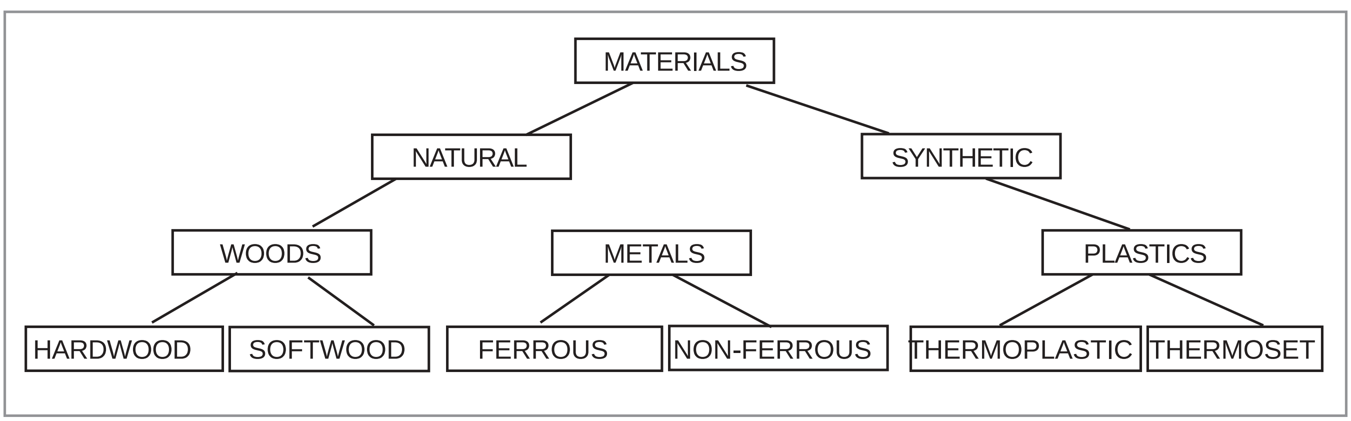
The nature of technology applies to creativity and design in the application of content learned in previous technology education courses and the introduction of new ideas and techniques. Impacts of Technology addresses standards related to the nature of technology in the following areas.

Natural vs. Synthetic Material Applications

Impacts of Technology allows students to design and build new products and systems that probably are not specifically detailed in working drawings that include a bill of materials. While research, systematic problem solving, and the application of a design process will help to specify materials, some experimentation will be needed to gain experience in the appropriate choice of materials.

Providing such experiences for students will address *STL* Standard 2 and Benchmarks I, J, K, Z, BB, and CC.

Teachers may need to review the possible choices or classification of materials using a simple chart such as the one below.



Properties of Materials

Additionally, experimentation with common building materials might be appropriate depending on the experience level of the class. Properties of materials such as those at the right might be included.

Material	Properties
• Medium density fiberboard (MDF)	Dense, no grain, good for jigs / fixtures
• Industrial particleboard	Inexpensive
• Acrylic sheet (Plexiglas®)	Bendable using strip heater
• High density Styrofoam®	Prototype construction using hot wire cutter

Using Tools

Impacts of Technology is a course that goes beyond the basics. This applies to the use of tools as well as materials. The safe use of a variety of tools not commonly used in previous classes might include the ones at the right.

Tool	Application
• Plasma cutter	Quick, safe, accurate metal cutting
• Pneumatic nailer / stapler	Strict student supervision required
• Hydraulic pipe / tubing bender	Useful for bending conduit, pipe, or tubing
• Hot wire cutter	Produces fast prototypes using Styrofoam®
• Stereo lithography	Makes 3-D models from computer designs
• CNC Mill / Lathe	Produced products from CAD designs

Solving Problems

Previous experience in practical reasoning or problem solving notwithstanding, this is one area where there cannot be too many activities. Chapter 2.1, Applying All Subjects Through Systematic Problem Solving, details the steps and applications of the technique. Teachers might notice that students feel they have mastered the problem-solving technique from previous activities. An analogy with sports might put things in perspective. If you play a few games of baseball (or any sport) are you now an expert? As with most things, practice in problem solving can help make the process more effective.

Exponential Growth of Technology

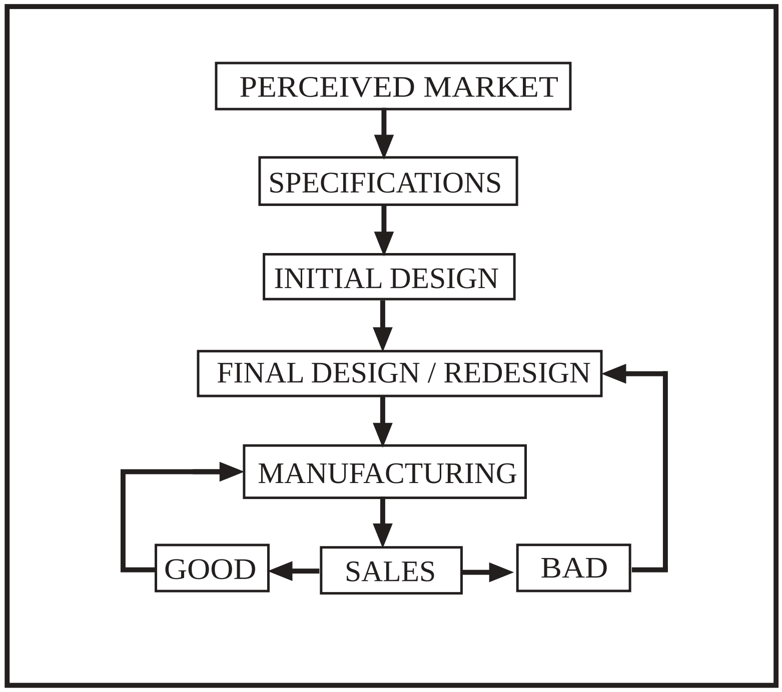
The rapid growth of technology can be intimidating to some and exciting for others. Students can gain an appreciation for the rapid advancements in manned flight since, for example, the Wright brothers. At the same time, students can be frustrated by the apparent lack of exploration of deep space as seen in science fiction movies.

Discussion along these lines relate directly to the assessment of technology further described in Chapter 3.1, Analyzing the Fundamentals of Technology Assessment. Students can appreciate that some technologies grow/expand very rapidly while others move at a frustratingly slow pace. An understanding of the actual nature of technology will help to put things into perspective.

Product Development

Considering the billions of dollars spent by teenage students each year, one might wonder how they decide to purchase shirts that are too short or pants that fall around their knees. Personal tastes aside, an appreciation for quality is an acquired trait directly affected by fads and peer pressure. When asked to analyze a product strictly from a practical manufacturing viewpoint, removing the advertising and subculture influence, students sometimes acquire new insight.

If the steps in product development are graphically illustrated, products can be analyzed in a new light. Students can relate to the fact that the first version of a product to reach the market is often quickly copied and improved with added features and better performance.



Creativity, Logic, and Innovation in the Design Process

The possibilities for creative design activities are limitless. Even specialized manufacturing areas such as a cleanroom glovebox are within the realm of technology education programs.

Creativity technique	Procedure
• Similar products	Compare and contrast an idea with existing products
• Brainstorming	Talk with a wide variety of people for insight
• Reverse thinking	Think about the opposite or negative of an idea

Creativity can be enhanced if ideas are analyzed from varying points of view. Evaluating ideas with regard to the following techniques can sometimes enhance and expand a design idea.

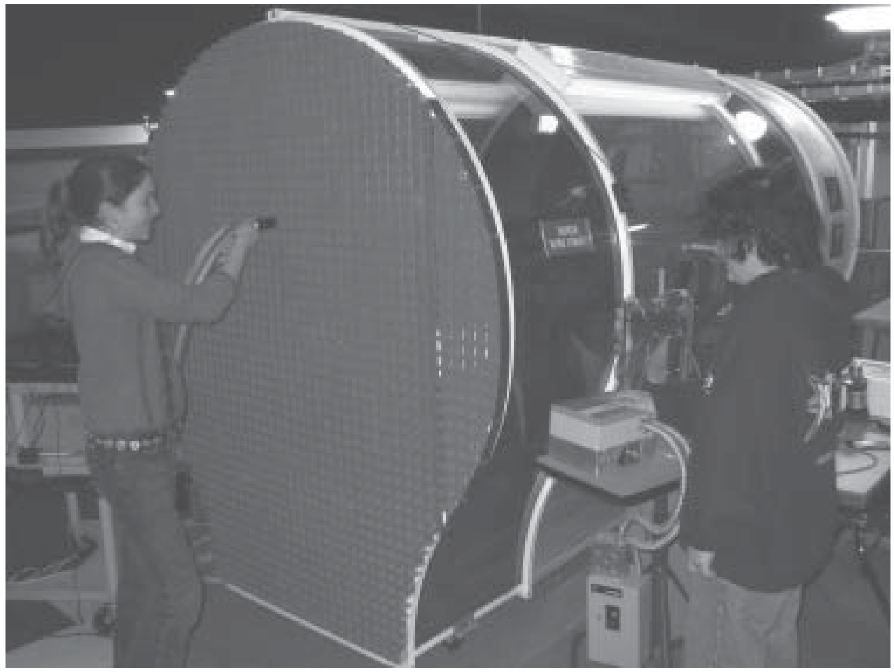
It has been said that there are very few truly new ideas or products, just imitations or variations of an existing product changed or used in a different way. Considering this fact, students should feel less pressure to think of something completely new and innovative.

Using a student-built glovebox to perform experiments can give students an understanding of high tech processes and systems. An inexpensive HEPA filter is used to produce an overpressure inside the glovebox. A hinged acrylic front panel provides access for large equipment or materials. A long-term goal is to produce working silicon transistors.

Technology Systems, Processes, and Trade-offs

One of the hardest lessons to learn in the design of products, systems, or processes is that the first solution to the problem will most likely not be the best. Students can get stuck on one idea and become close-minded to other ideas that offer better possibilities. Trade-offs are necessary to accommodate all possible ideas and are an important component of group interaction.

As an example, many trade-offs and compromises were made in the design and construction of a large wind tunnel in an Impacts of Technology class of high school students. Students were able to design a system to analyze airflow around objects using a non-toxic theatrical smoke source. A videotape of a student wearing a racing suit, helmet, skis, boots, and using special downhill poles can be investigated to determine the best possible "tuck" position, producing the least amount of drag. Other classes added a "hovercraft" platform in the floor of the wind tunnel to make direct measurement of drag possible, using a linear variable differential transformer (LVDT).



A human-scale wind tunnel was designed and built by students to test the drag forces on downhill skiers. A five-horsepower motor-driven fan is controlled by modulating the frequency of the current, making slow- and high-speed tests possible. The air is drawn in through an air-straightening grid to prevent turbulence and eddy currents.
(Photo by Brad Thode.)

Assessment Techniques

Analyzing the impacts of technology requires an open mind and the ability to remove any emotional attachment to the topic of investigation. This is sometimes as difficult for teachers as it is for students. Brand loyalty and traditional purchasing routines are hard to deny. New technologies are somewhat easier to assess because advertising and purchasing experiences have not had a chance to sway attitudes. Unbiased analysis of products, or technological systems, can be accomplished with simple techniques or procedures designed to consider all of the possible implications.

First, it is important to remove or attempt to reduce the influence of all of the factors that might affect the fairness of an assessment. Some of the factors that could inhibit a technology assessment include the following:

- Emotional – Being accepted as a part of a group is an important factor in our society. The feeling of belonging to a group that thinks alike is often stronger than any desire to voice a different opinion. This factor is much stronger in some cultures.

- Cultural – Each person is a product of his or her culture. Subtle influences and positive or negative reinforcements to statements or actions combine to form a kind of mental database of factors that are either acceptable or taboo.

- Intellectual – While not often a problem with students, teachers may try to over-think a technology product or system. Over-analyzing a topic can sometimes block the real facts.

- Environmental – The simple factors that affect our daily lives can influence how we feel during an assessment exercise. Students can be easily pressured by their peers into thinking a certain way. Time constraints may force a decision that would not otherwise surface.

- Perceptual – Each person perceives factors in a slightly (or sometimes vastly) different way. This fact is often demonstrated, for example, when eyewitness accounts of the same incident differ greatly among different people. Factors such as hearing impairment or colorblindness can change perceptions widely.

The Old Pro and Con Trick

Many business decisions are narrowed down to the good and bad factors listed on a simple chart. This same technique can be used to organize research data into pro and con categories. The following assessment technique can be used in an entire class or smaller groups to practice organizing data. This activity will address the following standards for technological literacy and corresponding Benchmarks: *STL* 1, Benchmarks J, L, M; *STL* 2, Benchmarks Z, AA; *STL* 4, Benchmarks G, I, J, K; *STL* 5, Benchmarks H, I, J, L; *STL* 6, Benchmarks I, J; *STL* 13, Benchmarks J, K, L, M.

1. Choose one of the following topics for a class topic or smaller group discussion:
   a. Nuclear power
   b. Sport utility vehicles
   c. Genetic engineering
   d. All terrain vehicles
   e. High-powered motorcycles
   f. Cosmetic plastic surgery
   g. Manned space flight
   h. Cashless society
   i. Personal watercraft
   j. Stun guns
2. Draw a vertical line on the board or have a group leader record the data on paper. Label the sides and record the Pro and Con responses to the chosen topic.
3. Brainstorm responses to the topic while trying to avoid undue influence from the blocking factors listed above.
4. Write all responses until it seems all ideas have been exhausted.
5. As a group, evaluate any questionable items that might be inappropriate or inaccurate responses.
6. Assess the resulting list and determine if there is an obvious pro-or-con result.

Discussing the impact of robotics on the future can be a realistic technology assessment exercise. Will jobs be lost as robots take over more manufacturing tasks? Should people be required to do the dull, dirty, or dangerous tasks that robots could do more efficiently?

Analysis of Data

Information overload is a real factor in the analysis of technology-related products or systems. Researching any topic has become a matter of a few mouse clicks rather than days spent in a library. Internet searches, in fact, often must be narrowed to reduce the number of sources or "hits" to keep the quantity of data manageable. Organizing the data into a graphic matrix / chart can make it possible to analyze data accurately.

Data Analysis Matrix

Viewing information graphically can make it easier to analyze or interpret. The following activity will provide a method of using bar graphs within a matrix to help analyze data.

The activity will address the following standards for technological literacy and corresponding Benchmarks: *STL* 3, Benchmark I; *STL* 4, Benchmark I; *STL* 5, Benchmarks I, L; *STL* 8, Benchmark H; *STL* 11, Benchmark P; *STL* 13, Benchmarks J, K, L, M.

1. Each student should choose a related technology topic from the following list:
   a. Energy sources (See sample chart.)
   b. Modes of personal transportation
   c. Modes of mass transit
   d. Biotechnology
   e. Space exploration vehicles
   f. Ocean uses and sustainability

Impacts of Technology – Analysis of Data Matrix

Name: ___________________________

Period: ________________ Date: ___________

Topic / Factors								
____________								
____________								
____________								
____________								
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____________								
____________								
____________								
____________								
____________								

Instructions:
Fill in each box as a bar graph. If you think the assessment factor is medium, fill in the box as shown. Boxes may be completely filled, left blank, or anywhere in between.

2. Use a blank matrix form and determine the types of technology and factors to be compared.
3. Treat each box as a bar graph and fill in the appropriate amount for each category (See illustration blank form.)
4. Analyze the resulting matrix for trends or obvious advantages or disadvantages.
5. Write an overall analysis of the technology topic based on the results of the matrix.

Learning to fly can be accomplished in many ways. The three flight simulators shown here could be analyzed using a matrix / bar graph method.

Impacts of Technology – Analysis of Data Matrix

Name: ____________________________ Period: ________________ Date: ___________

TECHNOLOGY ASSESSMENT FACTORS \ ENERGY SOURCES								
Cost to build plant								
Air Pollution								
Water Pollution								
Acid Rain								
Spent fuel storage								
Dependable source								
Cost per kilowatt hour								
Environmental Impact								
Renewable								
Long-term benefits								

Instructions:
Fill in each box as a bar graph. If you think the assessment factor is medium, fill in the box as shown. Boxes may be completely filled, left blank, or anywhere in between.

Energy Sources Matrix Chart Example

Chapter 1.4

Analyzing and Re-designing an Existing Product

Have you ever used a tool, kitchen utensil, or product that just didn't work as expected? Most people just accept the poor design and move on. Those people with the insight, skills, and ability to re-design products are called inventors. Most inventions are modifications of existing ideas. Those who wonder about a better way to make something are naturally creative people and are often more willing to learn about how technology affects them. Those who simply pay the bill and accept what technology does to them are possibly victims of an uncaring society. The "black box" of technology is feared by many and regarded as totally incomprehensible.

The first hurdle for students as well as teachers can often be as simple as accepting the fact that just because a product exists doesn't mean it is the best design. Quite often, the first is not always the best. This is as true of ideas as it is of products. The role of tradition is very strong in many industries and businesses. Traditions may be very short-lived, however. Try to purchase accessories for a four-year-old cell phone or replacement parts for a VCR, for example.

Teenage students are known to be taken in by fads and trendy merchandise. One pair of blue jeans may look the same as any other to the untrained adult eye, but a huge fashion mistake (in the eyes of other teenagers) can be made by wearing the wrong brand. Discussion along these lines can reveal the real differences between products and the fact that emotions often play a stronger role in purchases than quality or price considerations. What's cool and what's not will surely change along with the slang terms that describe what is considered good or bad. Discuss these topics with a middle level or high school class to determine the depth of their emotional attachment to products.

Product Analysis

A simple activity can illustrate how attached students are to only certain products based on visual appeal, price, durability, etc. The activity can also reveal the power of advertising.

This activity will address the following standards for technological literacy and corresponding Benchmarks: *STL* 1, Benchmark M; *STL* 2, Benchmarks W, L, AA; *STL* 4, Benchmark J; *STL* 6, Benchmark J; *STL* 13, Benchmarks J, L.

1. Ask each student to bring in an advertisement of a favorite product such as shoes, hats, clothes, sporting goods, snack / food products etc. Ads may be printed from the Internet or cut from magazines or newspapers. (Have a supply of magazines or newspapers available.)

2. Each student should have an ad for a product. Group the students according to the type of product. Each product group should sit together. Unique products can be grouped together.

3. Each group should elect a group leader to be responsible for leading discussions and keeping the entire group on task.

4. Students should present their reasons for choosing their product to the other members of their group. Discussion should be limited to two minutes per product.

5. Ads for each product should be available for group members to evaluate. Use the form provided to assess each product. (See Impacts of Technology – Analysis of Data Matrix Product Comparison Group Activity form on the previous pages.)

6. Each student should list the students in their group, their product, and the manufacturer in the appropriate blanks on the form.

7. Group discussion should focus on adding any other criteria needed to accurately evaluate the product types. Add the new criteria in the Other category on the form.

8. Each product should be assessed individually for each criterion. A maximum of 10

points can be given per criterion. Totals should be calculated for each product.

9. Rank the totals from highest (number 1) to lowest. Write the ranking in the appropriate blank on the form.

10. Group discussion should center on the following questions:

    a. Which product had the highest rating?
    b. Did anyone change his or her product preference?
    c. Will future purchases be evaluated differently?

Re-Designing Products

After students have had the opportunity to evaluate products using specific criteria, the re-design process is the next logical step. Using the data collected from the Product Analysis Activity, follow these steps to have students re-design a product.

This activity will address the following standards for technological literacy and corresponding Benchmarks: *STL* 4, Benchmarks I, J; *STL* 5, Benchmark L; *STL* 8, Benchmarks H, I, J, K; *STL* 9, Benchmarks I, J, K, L; *STL* 10, Benchmarks I, J, K; *STL* 11, Benchmarks M, N, O, P, Q, R; *STL* 13, Benchmarks G, H, I, J, K, L, M; *STL* 19, Benchmark R.

1. Using the same groups as the previous activity, analyze the ranking of products and determine the lowest ranked products.

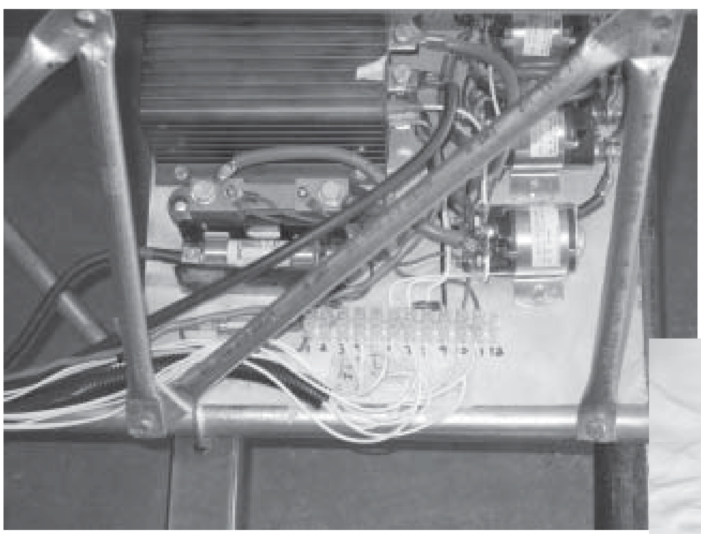
2. Each student should use an image from the Internet or scan a printed photo of one of the products.

3. Use graphics software to digitally modify the image. Cut and paste among other photos or draw features that would enhance the low-rated product.

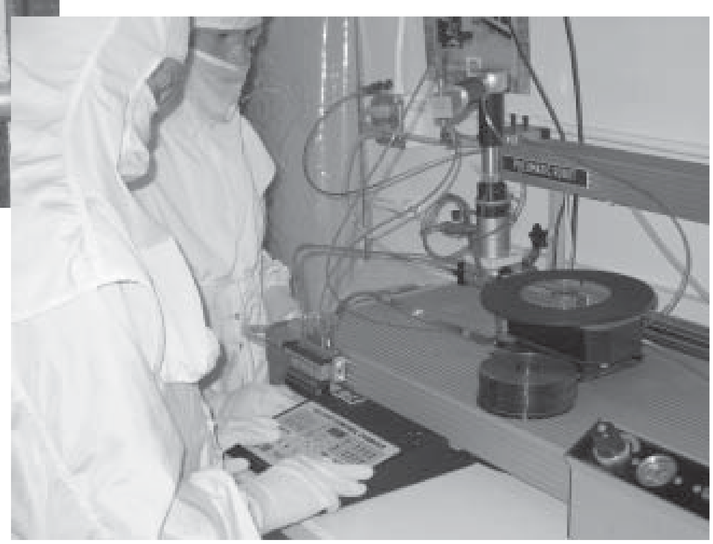
4. Print or project the re-designed product and explain the changes to the class.

5. The group should discuss the following questions:

    a. How would the design have been changed without the use of computer software?
    b. What effect will product changes have on the actual production of the product?
    c. Research the process of stereo lithography. How might the ability to "print" a 3-D model of a product affect the re-design process in the future?



A small change in an electronic circuit can have a large effect on performance. The process of re-designing products is very similar to designing a new product. This DC control circuit for an electric-powered Mars Rover must be re-designed carefully to prevent damage to components. Small changes in a real product may be too expensive to justify. Marketing departments thoroughly research the effects of changing a product before the re-design process is completed.



Re-designing a small segment of a production line can have an unwanted effect in the manufacturing process. Students in this photo are modifying a program on a programmable logic controller (PLC) that operated a pneumatic robot in the Technology Education Lab's cleanroom. Discarded CDs are used to simulate the production of silicon wafers used in the manufacturing of integrated circuits (ICs). Small changes in the programming will enable the robot's vacuum end effector to pick up a CD "wafer" and place it on a rotary positioning table for inspection.

Chapter 2

Delivery Methods

Chapter 2

Delivery Methods

Most teachers can appreciate taking classes in which they were given choices and felt in control of their individual learning process. Being treated as a professional and being given the opportunity to decide on a specific direction is an important part of the educational process. A similar appreciation can be felt by students if their needs and wants are given consideration in any class. Impacts of Technology is somewhat unique in that much of the content is student-driven. Students have the opportunity to propose specific projects that are technology-related and appropriate for the capabilities of the program.

The Role of Modular Instruction

While very popular and appropriate for introductory technology education classes, modular instruction methods are probably not applicable in an Impacts of Technology course that encourages creative design. The efficiency of the modular instruction method of delivering content can best be applied in providing basic experiences in a wide variety of technology topics. Impacts of Technology provides students with the opportunity to expand upon and combine various modular topics related to a complex project.

Empowering Students

Given the opportunity, students can amaze even the most seasoned teacher. Going beyond the basics and applying knowledge in ways the instructor never though of can make teaching even more rewarding for both the instructor and the student. This synthesis of information can take place at all levels. Student attitude toward learning is always a variable. Some classes are dominated by a prevailing attitude that learning isn't cool and being excited about school is out of the question. The key to this problem is to offer a wide variety of technology topics as possible creative design projects. The list of introductory activities below and the project spinoffs might help to illustrate the importance of a diverse Tech Lab. Please keep in mind that each project should be assessed to determine the impacts its technology will have on individuals, society, and the environment.

Student Leadership

Not only are students involved in the educational process of creative design, they are also responsible for directing the project. Transferring

Introductory Activity	Possible Impacts of Technology Project
• Make an audio CD	Start a student-operated radio station
• Assemble an electronic kit	Assemble an FM transmitter for the radio station
• Program a robot	Build an R/C Mars rover
• Produce a video	Build a video studio and start a student TV station
• Make a plastic product	Use a CNC mill to create an injection mold
• Grow a plant in science	Design and build a hydroponic garden
• Write a sci-fi story	Produce a science fiction video with animation
• Study genetics in science	Clone lettuce or isolate DNA
• Arc weld a lap joint	Design and build a flight simulator
• Make a claymation video	Make a cartoon with rendering / animation software
• Use a GPS	Organize an orienteering competition
• Use a laser	Make holograms
• Program a PLC	Design and build a work center

Middle level students program a robot to perform a pick-and-place operation on integrated circuits in a student-built cleanroom. A video camera in the background displays the activities of the students on a remote monitor. An inexpensive intercom system provided voice communication to answer questions or remotely evaluate progress.

some, if not most, of the responsibility for a project onto student managers can provide leadership opportunities to those students not usually accustomed to being responsible leaders in school. Technology education has always offered a chance for success to students of all abilities. Impacts of Technology can be a course where new leaders blossom and students have an equal opportunity to be very successful and proud of their accomplishments.

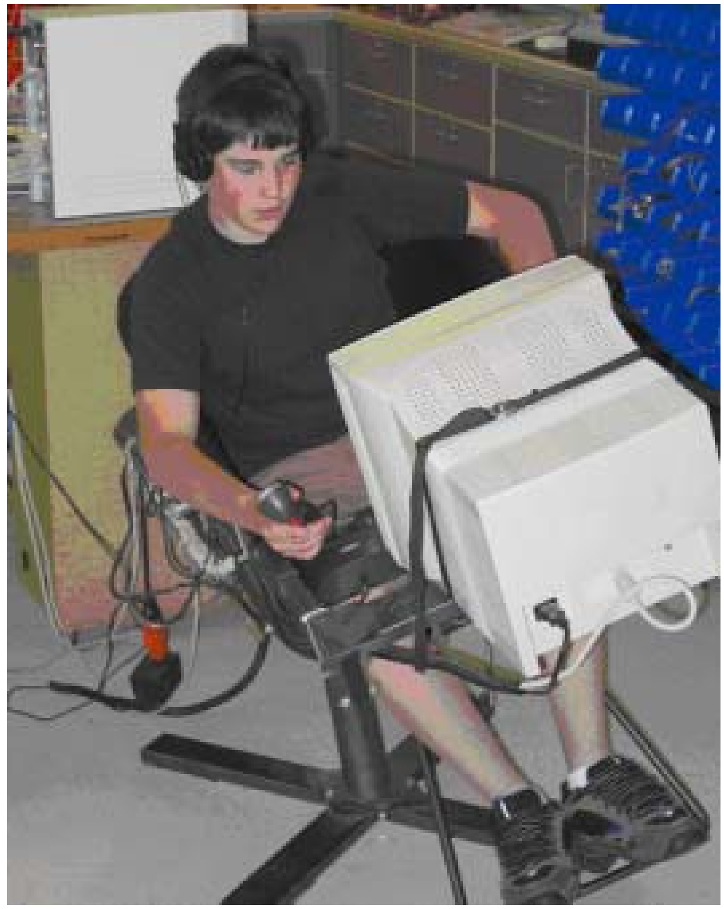
Pride and Ownership

Once the process is started and large, permanent projects are created, a sense of pride and ownership is subtly instilled in students. If students work hard to build a space station simulator, for example, they are very likely to return to the school after graduation and want to see the changes made to “their” project. This situation builds from year to year and eventually creates a large support base in the community. Leaving a legacy of a Mars Rover, for example, is much more preferable than leaving one’s initials carved in a desk.

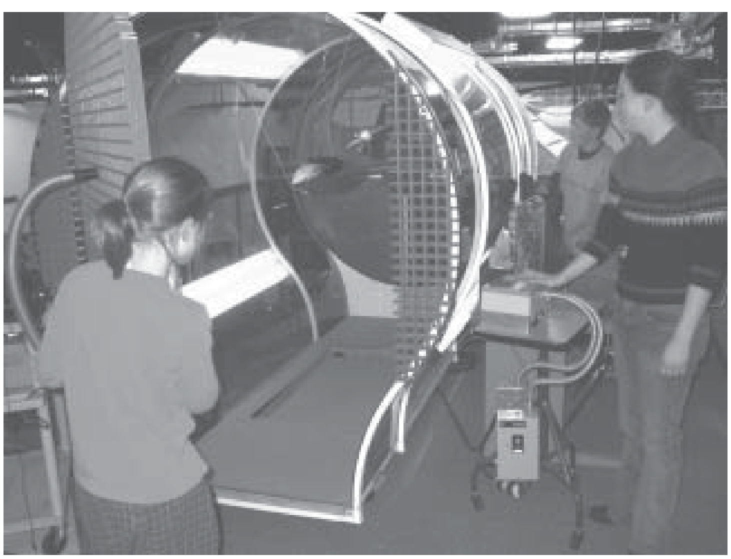
Former students involved in creative design often comment on how it was their favorite class or how they wish their college classes were as interesting. This rewarding situation only requires teachers to risk teaching a new class called Impacts of Technology.

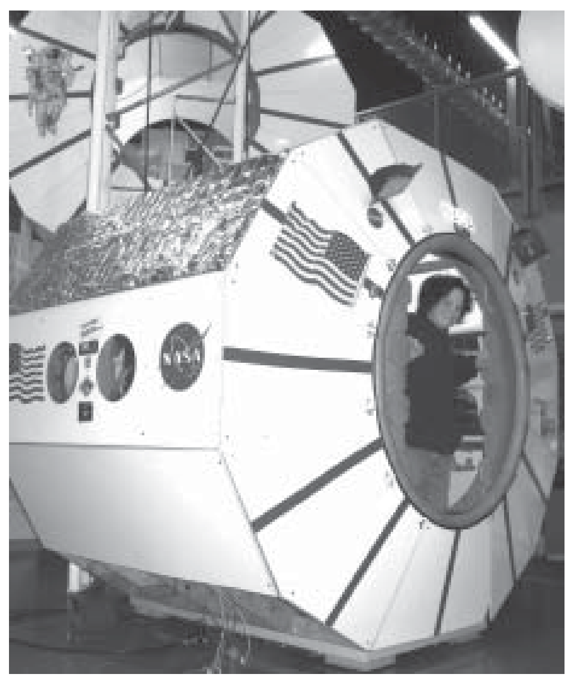
Technology Assessment

The technology assessment component of Impacts of Technology should be integrated with any delivery method. While assessment activities can be an interesting and challenging diversion, most students quickly get focused on a particular project and are understandably hesitant to stop the design process to analyze its potential impact. Teaching about the technology assessment process is similar to teaching about careers. It is more effective to discuss career information while students are experiencing activities related to a specific career. Trying to teach about a career in radio broadcasting, for example, is best covered just before or after an activity in which students actually produce a radio program. Technology assessment easily fits in with the design, fabrication, and testing of student-designed projects.



An introductory module involving Bernoulli's Principle might lead to an interest in how airplanes are controlled using a computerized flight simulator interfaced to a pneumatic chair. Impacts of Technology would go beyond these concepts to a large student-built project such as a human-scale wind tunnel, or even a space station simulator.





Chapter 2.1

Applying All Subjects Through Systematic Problem Solving

One of the most frustrating things a teacher can hear a student say is, "I can't do this… this is too hard…I quit." The reality of the situation often lies in the fact that many students have no idea how to start to solve a problem, what to do if their first attempt fails, and how to really use the information they learned in other subjects. When teachers try new activities and are understandably sensitive to student feedback (often very sensitive to negative feedback), they can get as frustrated as the students if the lesson doesn't proceed as expected. Students and teachers alike can benefit from a practical system that provides an effective method to attack any problem through practical reasoning.

Practical reasoning or problem solving is mostly common sense, but it is only of value if it is used often enough to become standard operating procedure. Many people have an immediate negative reaction when faced with a new challenge. Comments like, "I can't do this" often really mean, "I'm afraid to try" or "I've never had much success and I'm afraid to fail again." This defeatist attitude can be an indication of low confidence fostered by peer pressure and unintentional negative conditioning. Having a system of steps to fall back on can often help bolster self-confidence.

One of the most powerful attributes of technology education programs today and industrial arts programs of the past has been to provide all students with a feeling of accomplishment and self-worth. A teacher's attitude toward the students has always been key to a successful course. Whether the assignment involves designing, building, or testing an idea, students respond very favorably to a teacher who is enthusiastic about learning *along with* the class. When students try to solve a problem along with the teacher (instead of in spite of the teacher), attitudes change and confidence grows. A step-by-step approach to solving problems, or practical reasoning, can be a powerful tool for teachers and students to use when faced with a new dilemma. The important thing to remember is to keep an open mind to student ideas—no matter how strange they might sound. The following classroom example illustrates how teachers can learn along with students:

Classroom Practice: Keeping an Open Mind

Giving students a glimpse at a possible future technological breakthrough is an exciting activity in which there are no wrong answers. The topic of superconductivity and the associated demonstrations can give students a real design experience. Superconductor demonstration kits are available from various education sources (see Chapter 5) for a reasonable price. The only additional supply required is liquid nitrogen.

Considering the impact of semiconductors on our society in the last 50 years, this topic could be an important technology education and science correlation. Science classes often discuss the electrical properties of materials and skip over some of the most important technological applications by oversimplifying the properties of materials into just two groups: insulators and conductors. The fact that much of our technological world relies on semiconductors (computer CPUs, integrated circuits, RAM/ROM memory chips, etc…) should merit more discussion. There is, however, more to the subject.

Superconductors are materials that have zero resistance to the flow of electricity. This property could change every electrical device for the better, making it more efficient and saving vast amounts of electricity. While superconductors are easily manufactured today, there is an obstacle to their widespread application: they only work at very low temperatures. In order to lose resistance, superconductors must be cooled to the temperature of liquid nitrogen (-321ºF).

Electrical Properties of Materials
- Insulator
- Conductor
- Semiconductor
- Superconductor

The demonstration kits available for school use show how a dramatic test can determine if a material is really a superconductor. The test involves cooling a superconducting disc in liquid nitrogen and placing a small, rare Earth magnet on top, where it levitates! This demonstration is dramatic enough and leads to discussions of future applications, from levitating bearings that don't require lubrication to hovering shoes on special tracks.

This demonstration and discussion is not only interesting and surprising to students, but it gives them a chance to apply science principles and predict how superconductors might affect their future…predicting how they might be used when the low temperature requirement is solved. A writing assignment in which students can describe a possible application of room temperature superconductors of the future or a detailed sketch of their ideas in art class are interesting student activities. By itself, this demo would be enough, but there's more.

After demonstrating the levitating magnet, one class had many questions and predictions. One student, however, was fascinated with liquid nitrogen and lost track of the concept of superconductors. His questions were well thought-out and not just attention-getting. In particular, he wanted to know what would happen to liquid nitrogen in a vacuum, having remembered a previous demonstration in which water in a beaker was made to boil at room temperature using a bell jar and a vacuum pump.

Feeling that the discussion and demonstration of superconductors had been lost on this student, the teacher was a bit frustrated, thinking that liquid nitrogen in a vacuum would just rapidly boil off into a gas. Rather than dismiss the idea totally, however, there was just enough time left in class to say, "I don't know what will happen, let's try it…" A small amount of liquid nitrogen was quickly poured into a shortened foam cup and placed into a bell jar. The vacuum pump was started and the entire class watched carefully. As predicted by the teacher, the liquid nitrogen began to boil off very rapidly, but just as the bell rang at the end of class, the liquid in the cup instantly froze into what looked like large ice crystals! We had changed liquid nitrogen into solid nitrogen! Not sure why this happened, the teacher was probably more amazed than the students. After further study, it was found that the freezing point of nitrogen is just a few degrees less than its liquid phase. The rapid boiling or evaporation in the vacuum reduced the temperature in much the same way rubbing alcohol makes skin feel cooler.

Had the teacher simply dismissed the student's question as being silly, an incredible learning opportunity would have been missed. By listening to students and keeping an open mind, learning can be an exciting experience for students and teachers alike.

Safety Note

Read and follow the safety precautions and instructions that accompany the superconductor kit. Liquid nitrogen must be stored properly in a DeWar flask, and students should not be allowed to experiment without adult supervision. Chemical goggles should be worn, and a Materials Safety Data Sheet (MSDS) should be kept on file.

Practical Reasoning Steps

If there were enough time to analyze how problems are solved successfully, an individual pattern or approach would emerge. The process of practical reasoning can be reduced to just a few simple steps. This is the common sense aspect that seems simple, but is often forgotten when new problems occur. Basically, new problems are solved using a series of steps such as:

1. What's the problem?
   If you don't know what to solve, it will be hard to know if the answer is correct. Detailed problem statements can be very complex design briefs or specifications that outline the desired outcome.
2. What do you already know?
   This is where all of subjects taught in school can be put to use. It cannot be assumed that students will apply the knowledge gained in other subjects to a specific problem. Correlations must be pointed out and cross-curricular examples should be constantly encouraged.
3. Where can you learn more?
   Research, ask experts, search the Internet—there are many sources of information. The first source should not be the sum of a student's research, however.
4. Put the information you know to work.
   Try to solve the problem with what you have learned so far. This is where experiments are tried and knowledge is gained. Even a failed attempt is

important…you know what doesn't work, so a new direction should be taken.

5. What happened?
   Evaluate the results of your first attempt. Students often have difficulty admitting that their first ideas did not yield the best possible results. While this stage can be frustrating, it often means ultimate success or failure.
6. How could the solution be better or different?
   This is where failure is not an option. When the first solution doesn't work, the idea to is apply what you learned toward a new solution. From this point it is often required to start over at step two.

While the steps may change with various problems, the underlying idea is to know what to do to avoid the initial frustration often associated with a new challenge. The repeated application of a systematic approach can help bolster student (and teacher) confidence. The one essential component is what happens when the first solution fails. The quest for instant gratification is common among students and adults, but real success comes from learning to treat failure as a learning experience.

Impacts of Technology lends itself perfectly to the application of practical reasoning. Whether the project involves futuristic imaginative predictions, engineering simulations, or historical reconstructions, the process can be as important as the end results. Following are two examples of practical reasoning in action. These examples address standards for technological literacy and corresponding Benchmarks: *STL* 8, Benchmarks H, I, J, K; *STL* 9, Benchmarks I, J, K, L; *STL* 10, Benchmarks I, J, K, L; *STL* 13, Benchmarks J, K, L, M.

Example 1
WORK IN MICROGRAVITY
Middle school practical reasoning simulating and astronaut performing an EVA (Extra Vehicular Activity) or walking on the Moon

Idaho middle school teachers, Brad Thode and Doug Walrath, challenged students to design, build, and use a simulator that gives students the feeling of being on a space walk or on the Moon. The entire project was completed in a 12-week class with assistance from a $200 mini-grant and donated equipment.

What's the problem?
Students can watch astronauts during an EVA (Extra Vehicular Activity), or space walk, but they have a difficult time truly appreciating the microgravity environment. The problem is to design, build, and test a device that will simulate the feeling of microgravity in a 1G techlab.

What do you already know?
Microgravity is an environment of reduced gravity. While the phrase "zero gravity" is sometimes used, there is always a small amount of gravity affecting spacecraft and the people who work in space. A work platform that rides on a cushion of air will greatly reduce the friction associated with 1G. The challenge is to design an activity that will simulate µg (microgravity) and be adjustable to allow students to experience less than 1G.

Where can you learn more?
There is an incredible amount of information on the NASA Web site (www.nasa.gov). The original idea for this apparatus was seen on a televised documentary of short science topics.

Put the information to work.
Human muscles work like elastic cords in that they can stretch in length. Using bungee cords to replace muscles, this µg simulator can also be adjusted to simulate the gravity on the moon or other planets. The simulator is easily made using quick connecting rock climbing equipment and a back packing frame for back support and comfort. The bungee cords do not attach directly to the student, making an emergency exit quick and easy. By changing the normal *up* position to horizontal, it was possible to have students walk on a vertical treadmill. Gravity could then be controlled by adjusting the tension holding the student astronaut to the treadmill ($1/6^{th}$ of the student's weight would simulate walking on the moon.)

What happened?
Students using the µg simulator soon found that a bouncing stride worked best for walking in $1/6^{th}$ G. NASA archive video footage showed this movement similar to the Apollo astronauts during lunar explorations. Another unexpected result came after just ten minutes of a spacewalk. Students reported a strange feeling of "too much gravity" when they stood up to remove the backpack frame. This feeling was associated with what astronauts must feel when returning to 1G. Discussions of the effects of µg on the human body included bone mass loss and muscle atrophy.

Microgravity Simulator
Photo by Brad Thode

How could it be better?
A rapid method of adjusting the tension on the bungee cords was needed to make it possible for many students to try the μg simulator in one class period. A student suggested a type of cord adjuster found on some tents, and it worked perfectly. Future modifications might include a heart rate monitor or video goggles showing the surface of the moon or Mars to make a virtual-reality experience.

Safety Note

Students are not tied directly to the μg simulator bungee cords. The backpack frame belt and straps are easily adjusted and released. Loose slings are used around the knees and ankles. A pad is placed under the student astronaut for safety and comfort. All connections are made with quick release carabiners in case of an emergency. Two spotters are required to adjust the bungee tension evenly. A treadmill kill switch is held ON by the student astronaut. If the switch is released, the treadmill stops immediately. Teacher supervision is required.

Example 2
INVESTIGATE A CRIME SCENE

High School Practical Reasoning involving History, Technology Education, Science, and Math

Vermont technology education teacher, Tom Keck, introduced his students to forensic technology by reconstructing the scene of President Kennedy's assassination. Students researched that terrible moment in history, built scale models of the crime scene and used lasers to simulate bullet trajectory.

What's the problem?
Was there more than one assassin involved in the killing of President Kennedy? Were shots fired from more than one location in Dallas?

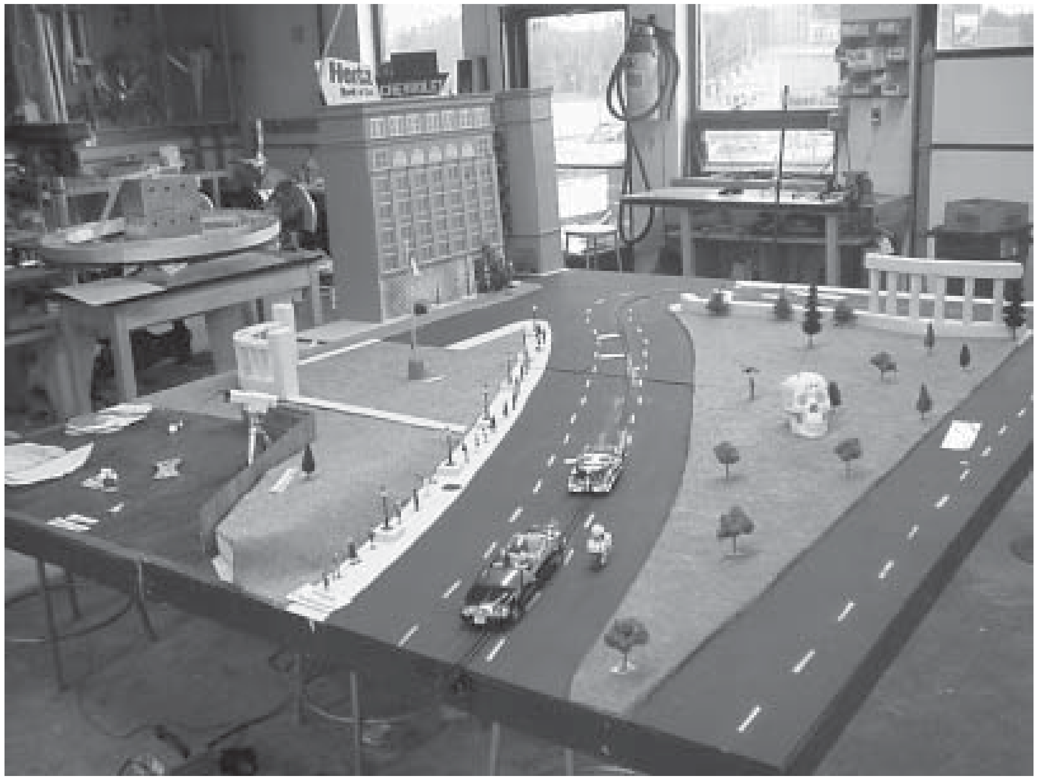
What do you already know?
The Warren Commission provided a detailed accounting of the Kennedy assassination that has been questioned for many years. Conspiracy theories have been offered to account for the discrepancies in the official report. Books, movies, and documentaries have dealt with the topic.

Where can you learn more?
This is one of those topics that yield thousands of hits in an Internet search. A selected reading list of resources should be developed by the teacher with the help of the school media specialist.

Put the information to work.
Researching the crime scene and building a scale model provided a real-world feeling to the student investigation. Forensic recreation of the Texas book depository, grassy knoll, limos, and other details added authenticity to the project. Small helium-neon lasers were used to indicate bullet trajectory.

What happened?
While this topic may be the subject of debate for additional classes for many decades, students had a chance to draw their own conclusions based on scientific facts.

How could it be better?
Future possible investigative techniques might involve recreating the scene using computer graphics and three-dimensional animation.



Dallas Recreation
Photo by Tom Keck

Frustrating Classroom Situation

A technology education teacher is excited about having students compete in a hovercraft race. The teacher uses a recycled CD, wooden dowel, and balloon to demonstrate the hovercraft to the class and gives them an assignment to design and build the fastest hovercraft.

Unexpected Results:
Even though the teacher has given the class an enthusiastic introduction to the assignment, the results are disappointing, as every student makes a hovercraft identical to the example. Student excitement has diminished because they are all doing exactly the same thing. Race results seem to be more related to the amount of air in the balloon rather than careful design and construction. The lesson is less than successful.

Alternative Approach:
Experienced teachers reading the scenario will immediately think about omitting the teacher's example so students couldn't copy a set solution. While this may help, there are additional ways to prevent copies. Teachers are often discouraged with this type of activity because it always seems that one student gets an idea and, like magic, everyone in the class has the exact same idea. Arguments about who had the idea first break out, and the frustration level of the class begins to rise. One way to overcome this situation is to require students to simulate the real world through a patent application. Students must design, describe, and draw their individual idea on a patent application form.

The teacher or a trusted student can be the patent officer who evaluates, signs, and records the time and date for each application. If another student tries to patent exactly the same idea, the patent officer can reject the idea or refer the applicant to the patent holder for negotiations. The patent holder may "sell" part or all of the idea in the form of grade points. If the assignment has a total of 100 points, for example, a patent holder may offer to license part of his or her idea for 10 points. The patent holder has the potential of getting 110 points for the assignment, and part of the idea can be used by others who can receive a maximum of 90 points. The patent applications can even be kept on file from class to class, requiring students to find new solutions to problems in the future.

Multidisciplinary Application

One aspect of teaching that is often overlooked is making sure students know why they have to learn the lesson being taught. It is easy to get caught up in the race to cram for the standardized tests and forget to make the learning process relevant. Preparing students for the real world requires knowledge of the "big picture" of how all subjects work together. Correlation is most effective if teachers can agree on assignments that involve multidisciplinary aspects—language arts credit for the technical writing component of a technology education assignment, for example. Here are examples of how other subjects can be tied together in a technology education activity. These examples address standards for technological literacy and corresponding Benchmarks: *STL* 3, Benchmarks H, J.

Language Arts

Describing a complex project idea in words can be difficult even for professionals. Technical writing is a valued skill in the real world and one well worth cultivating. As with all aspects of technology, the complexity of a project can be reduced by dividing the whole into systems and sub-systems. Taken in smaller bites, even the most complex idea can be broken down into palatable portions for all to understand.

Art

Technical illustration is a natural correlation to the design process, but three-dimensional sculpting of prototypes may be appropriate in some situations as well.

Math

The basics of algebra or geometry are too often taught in theory, but their application in the layout of materials is a natural integration with Impacts of Technology.

Science

Did you ever wonder why you had to identify rocks and minerals in Earth Science? A broad background in understanding the natural world can help widen the understanding of our environment and provide background for technology assessment. A possible science/ technology integration activity might be to design and build a working model of a mineral extraction milling process.

Music

Activities centering around video and radio broadcasting provide a natural opportunity for students to demonstrate musical abilities or interests. A challenge of using an electronic keyboard to compose an introductory theme to the school news broadcast can bring instant recognition to a talented student.

Literature

Working along with a literature teacher to include a technology-related, non-fiction reading assignment can benefit both disciplines.

Physical Education

Data acquisition software can be used in technology to quickly take the pulse of P. E. students. Over an extended training period, a spreadsheet application can be used to store and graph a student's fitness level.

Family and Consumer Science

Possible activities related to the field of biotechnology include: design and create a healthy food snack, develop alternative food packaging techniques, or design a virtual kitchen that might be wheelchair accessible.

Classroom and Lab Management

Beginning teachers learn quickly that one key to preventing problems in the classroom is to keep students actively engaged. It is no secret that students who are excited about learning and involved in the process are less likely to cause discipline problems. While this is helpful knowledge, the real key to learning lies in the methods teachers use to keep students excited and involved.

One important component of a successful technology education program is the empowerment of students to direct their own learning. This is accomplished by requiring them to make meaningful decisions regarding their individual learning processes. The direction and pace of learning are the determining factors. Giving students a choice of topics and a fair assessment process will provide a greater sense of involvement and interaction.

Scope and Sequence

The popularity of modular instruction in technology education has increased at both the middle and high school levels. This delivery method has become so common that a void exists in many programs. The question is often asked, “What do we do after the modules?” Impacts of Technology can help to fill this void and answer the question of what to do after a modular program. In addition, programs in smaller schools can often get twice the use of the equipment purchased for modular instruction by using it in Impacts of Technology. This benefit can help to stretch shrinking budgets and increased enrollment.

A typical sequence of courses leading up to Impacts of Technology might include the following:

Technology Education Course Sequence Model

High School 9-12
12-36 Weeks

Impacts of Technology (10th - 12th)[6]
Introduction to Engineering (10th - 12th)[6]
Issues in Technology (10th - 12th)[6]
*** Foundations of Technology (9th)**

Middle Level 6-8
12-18 Weeks

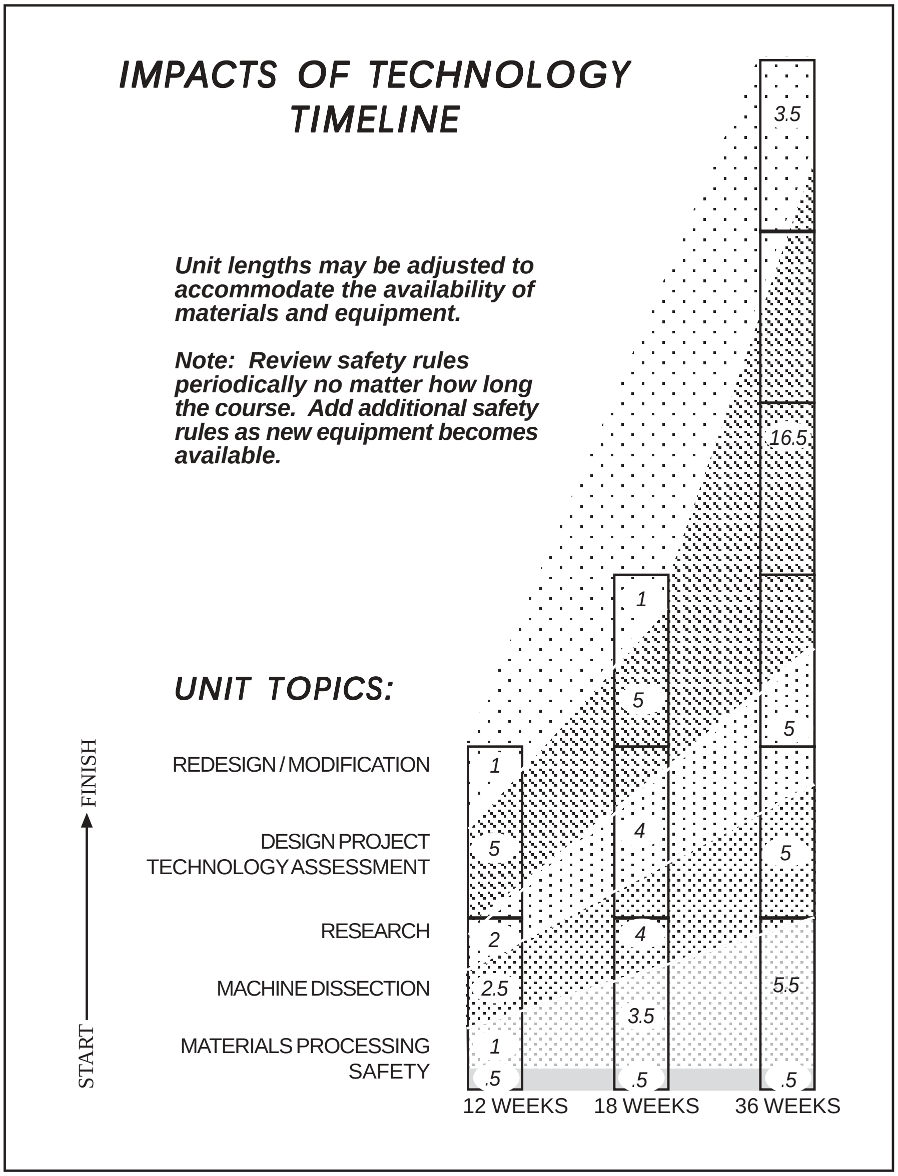
Advanced Tech (8th)[5]
Engineering (7th - 8th)[4]
NASA Tech (7th - 8th)[3]
Tech (7th - 8th)
Publications (7th - 8th)[2]
*** Intro to Technology (6th)**

Elementary K-5
12-36 Weeks

Production (5th)[1]
*** Technology (K - 5)**

*	Required of all students
1-2	Includes video news, printed and video yearbook production
3	Technology Education with an emphasis on aerospace
4	Technology Education and math correlation
5	Impacts of Technology
6	See ITEA/CATTS model course guides

The pacing of an Impacts of Technology class depends on its duration. The timeline at right is suggested for various course lengths.



Safety First

The starting point for any course involving the use of equipment must be an emphasis on safety. At the middle and high school levels, students can become more involved in this topic as well. Secondary students who have had previous technology education courses often feel that they know all there is to know about safety. Some ideas that can renew student interest in learning about safety include the following. These ideas address standards for technological literacy and corresponding Benchmarks: *STL* 12, Benchmarks I, O.

- Challenge students to analyze the best emergency escape routes and then compare their ideas to the official plan to make the process more interesting.
- Invite the local safety inspector or fire department official to discuss little known or often overlooked safety considerations.
- Create safety posters by taking digital pictures of a staged accident. Teachers should monitor the ideas and ensure that machines are unplugged during the photo session. Use graphics software to digitally enhance the photos for maximum effect. (Note: This assignment can get a bit too graphic for some students. Teacher supervision is the key to the success of this activity.)
- Involve advanced students in the creation of a computerized safety test. Students who have had to take the same safety test for other courses are often frustrated by doing the same test again.
- Research the most common school setting in which students are most likely to be accidentally injured. Find out what grade level has the most injuries. Determine if girls are more accident prone than boys. Analyze records to find out what time and day of the week seem to have the most accidents. Discuss the findings with the students.

Technology education teachers need to address safety as a critical aspect of their teaching duties. Safety tests should be completed successfully by every student and kept on file. Special needs students should be given ample opportunity to complete the test. Here are some suggestions:

- Read the questions orally to students with reading difficulty. Write answers as dictated by students with writing difficulty. Have another teacher or aide help in the process and sign and date the completed test.

- Provide the test in the appropriate language for non-English-speaking students.

- Videotape the discussion of safety rules and provide the tape for loan to students who might need review before the test.

- Record the verbal test on tape and keep the tape on file.

- Make special arrangements, as required, to have a teacher or adult aide present when students use power tools.

- Consult the student's teacher to develop an appropriate adaptive program. Invite the teacher to accompany the student(s) to class. Investigate the use of parent helpers where appropriate. Attend IEP meetings to determine individual needs and possible adapted materials.

Assuming all of the students in the class have successfully passed the safety test, and the appropriate parent permission forms are on file, it's time to start the course content. Impacts of Technology can be taught in a standard classroom, but the more variety of equipment and materials available, the more opportunities students will have to explore their ideas.

Getting Ready for Impacts of Technology

One of the problems that teachers face when trying to prepare for the myriad of possible topics that an Impacts of Technology class can dream up is how to stock up on the nuts and bolts that might be needed. This activity will not only provide a stockpile of small parts, but it will also teach the appropriate use of hand tools and an understanding of the four energy systems[1]. The activity addresses standards for technological literacy and corresponding Benchmarks: *STL* 16, Benchmarks K, M, N.

Machine Dissection—The Perfect Activity for Starting Creative Design

Teachers just starting this activity may worry about not having enough machines to dissect. As soon as word gets out that old machines are needed for a school project, the problem is not a lack of machines, but where to put all of the donations. Some ideal candidates for the dissection activity include:

- Computers
- Printers
- Scanners
- Copiers
- Lawn mowers
- VCRs
- Tape recorders

Safety Note

It is not recommended to disassemble old televisions or computer monitors, or any device with a CRT (Cathode Ray Tube) as they contain high voltage capacitors that could cause a shock. The capacitors can hold a charge even though the device has been unplugged. Certain copiers also contain hazardous materials that should be handled carefully. All unusable parts should be recycled or properly disposed of.

Specialized tools may be required for some machines. Older computers, for example, require a very long Allen wrench to open the case. Torx, square, hex head screwdrivers, metric tools, snap ring pliers, penetrating oil, and screw extractors are just a few of the specialized tools that should be available. Student frustration can run high if the proper tool is not available. In a rush to complete the assignment, hammers and tin snips can be a tempting alternative to the correct tool. Students must be cautioned to use the proper tools and reminded that the assignment involves machine *dissection*, not machine *destruction*.

The assignment entails having students work in small groups to disassemble various machines and identify the parts by name. The parts are listed according to their proper systems. The four systems include:

[1] Principles of Technology series, AIT (see Chapter 5.1 Textbook References)

Mechanical
- Fasteners (nuts, bolts, screws, etc.)
- Washers
- Frames, baffles, supports, brackets, etc.

Electrical
- Motors
- Integrated circuits
- Transistors
- Resistors
- Capacitors
- Wire harnesses

Thermal
- Heat sinks
- Fans
- Heat shields
- Vents
- Heating elements

Fluid
- Pneumatic cylinders
- Hydraulic cylinders
- Pumps
- Compressors
- Valves

The parts should be kept in lockers, boxes, or plastic bags as available. The completed dissection project should be presented to the entire class so that all students can benefit from the unique parts of each machine. Inexpensive plastic or cardboard bins are available to sort the parts for future use.

Evaluation might include points for presentations, component parts and tool identification quizzes, and a rubric that assesses group participation. Tool and component identification quizzes in a large class can be difficult with very small parts. Solutions to this problem include:

- Have students build a display board with numbered components to serve as a quiz station. Develop answer sheets and have a student aide monitor the quiz as groups complete other assignments.

- Take close up digital photos of components and tools to be used in a computer-projected quiz. Involve students in the creation of the quiz using presentation software.

- Give an oral quiz to each group as they complete their dissection activity.

As word spreads that you are looking for donated machines, some very interesting items can appear at your door. While some donors are just happy to help, others may ask that a letter be written and a value be placed on the items. Teachers should be careful to follow district policy regarding donations and inventory regulations. Whether the donated item proves to be a treasure of useful parts or dumpster fill, community support should be appreciated with a follow-up, thank-you letter or newsletter acknowledgement.

Some old machines have particularly useful components for Impacts of Technology projects. Here are a few examples:

- VCRs – Some VCRs have a built-in, low voltage motor/ gear drive that can be used as a small winch without any further adaptation.

- Copiers – In addition to the motors, chains and sprockets, and solenoids, copiers have a unique part that is very delicate and useful. The front surface mirrors found in most copiers are ideal for working with helium-neon lasers. The reflective surface is on the front of the glass, preventing refraction of the laser light. Because the reflective surface is not protected by glass, it is important to prevent possible touching or scratching. The surface cannot be cleaned easily and scratches will destroy its reflective qualities.

- Printers – Experimenting with stepper motors can be very useful in robotic applications. The stepper motors in printers can help reduce the costs of trying various solutions to robot drive mechanisms.

- Teachers soon find that their budget can be stretched at state or local industrial surplus outlets. These agencies can offer a gold mine of tools and equipment for an Impacts of Technology course.

Assessment

Receiving a grade on an assignment is a personal and emotional experience for most students. While some will feign disinterest because it may not be considered "cool" to worry about grades, most students can be shown the importance of grades when they understand that they are competing against other students of the entire world, not just in a local school or classroom. A simple explanation of the fact that what you *learn* is directly related to what you will *earn* can bring an increased sense of awareness, albeit temporary.

After discussing the importance of grades and the need to try harder, students respond favorably to a fair evaluation system that is used often enough to prevent surprising drops in performance. Whatever system is adopted to manage grading in a technology education class, students should never be handed a grade without one-on-one discussion with the teacher. A short interview regarding accomplishments (or lack of) helps to keep students from forming negative attitudes or feeling that they are just a student number rather than a valued class member. One system that has proven to meet these requirements is the use of portfolios as discussed in Chapter 2.3. (Assessment rubrics are provided in Appendix D, beginning on page 100 of this document.)

Chapter 2.3

Portfolio Assessment

Many technology education teachers find the assessment process tedious and frustrating. How can you evaluate students accurately in an action-oriented lab setting? One method that has many additional benefits is the use of individual student portfolios. This method has proven to be successful because of its adaptability to teacher needs and student acceptance.

Portfolios are more than a three-ring binder used for papers. Here is a typical table of contents for a “Tech” portfolio:

Page	
1	Assignment List/ Grade list
2	Tech expectations
3-25	Tech Notes
25-30	Technology Terms

Advantages of a portfolio assessment system include:

- Instant student accountability.
- Easy progress check for teachers and parents.
- Students know their grade every day.
- Completed portfolio can be taken home.
- Performance-based, difficult to cheat.
- Inexpensive binders can be re-used.

Using Educational Technology in Technology Education

Portfolios can also be electronic instead of paper-based. Some textbooks offer electronic portfolio software (see Chapter 5, Appendix C, Instructional Resources). Loss of paper-based portfolios is avoided by insisting they are not allowed to leave the classroom. Saving student work on a computer network is only practical if consistent back-up procedures are followed. A high degree of frustration occurs when student work is lost for any reason.

The use of PDAs (Personal Digital Assistants) in business has filtered into the school setting. A palmtop computer can be used effectively to

TOPIC: Mars Rover, OBJECTIVE: Remotely control a Mars Rover simulator to search for signs of life on Mars. (This Mars Rover was built by middle school technology education students using an R/C model truck kit, a 12 volt DC video camera, and wireless transmitter. The video signal is sent to “mission control” in another part of the Tech room. A separate servo, transmitter, and radio using a different frequency is used to control the robot arm on the rover.)

record both grades and performance rubrics. However, many teachers find the use of computer-based grading systems to be redundant and time-consuming. Barcodes can be used for student names and assignment titles to facilitate the grading process.

Portfolio Procedures

Classroom procedures for portfolio assessment are simple. Here are the basics:

- Portfolios are not to be taken home.
- Different color binders can be used for each period or group of students.
- Name tag holders on the binder include student name and period.
- All portfolios must be returned to the appropriate shelf at the end of each period.

Classroom Scenario

Students enter the class and immediately take their portfolios from the shelf and sit down for attendance. Permanent signs for Topic and Objective should be placed on the board so students anticipate a new assignment; for example:

Topic	Animation
Objective	Use computer software to create a 30-second cartoon with sound.

Accurate record keeping is an important component of assessment. One of the important skills that teachers often find lacking in students is the ability to take useful notes. An effective method for guiding students toward greater note-taking skills is to develop a standard form or TechNote sheet. Students copy the topic and objective on their TechNote sheet and place it in their portfolio. Other items on the TechNote form include the following:

- Procedure – Students are guided through the process of listing the sequence of steps related to the assignment. Beginning students may require a sample list written on the board for the first few assignments.
- Drawings / Sketches – At least one half of the page should be left open for students to make a sketch of the apparatus involved in the assignment.
- Safety Rules – Specific rules or reminders related to the assignment are written in a prominent place on the TechNotes sheet.
- Questions regarding the assignment.

Review questions are used to assess student understanding and promote higher-level thinking. Questions might include the following:

- How could the topic of the assignment be used in another

Technology Notes

Name: ______________________

Date: ______________ Period: ________

Topic: ______________________

Objective: ______________________

Safety Rules: ______________________

Procedure: ______________________

Assignment Number: [ ]

class? – If students are unable to see other uses for the topic, the assignment should be deleted or modified.

- What was the objective of this assignment? – A simple question requiring students to recopy the objective can help to focus thoughts.
- How could this topic be used in the real world? – Practical application of the topic is an important part of technology education activities.
- What occupations are related to this topic? – Students must be directed toward thinking about their future. Requiring a listing of related careers centers their attention to occupational planning.

Monitoring Performance

The portfolio assessment process provides a foolproof method for monitoring student performance. One-on-one interviews with students give the teachers a chance to quickly learn about individual learning styles and adapt instruction. Students are required to show the teacher how they completed the objective. If the assignment involved programming a robot, for example, the student would ask the teacher to see the robot function successfully. If assignments are lacking in quality or accuracy, students are directed to review their work and modify their answers before credit is given.

A list of all of the assignments is kept in front of the class for each period. Students are required to keep a copy of the same list as the first page of their portfolio. The completed assignments are graded, and the teacher marks the grade, initials the grade sheet, and writes comments as needed.

Mid-term and final evaluations occur every six weeks based on the number of assignments successfully completed. Letter grades are based on a percentage of completed assignments. Every day, students know their grade standings and have the opportunity to attend an open lab before school or during lunch.

Students are given ample time to work on any assignment presented to the class. The teacher's challenge is to stay one assignment ahead of the fastest students. There should never be a time in which students feel they do not have any work. Some accelerated groups may complete more assignments than average. The order of assignments can be based on student interests, current events, or teacher-selected sequence. Teachers must be adaptable to the fact that there may be over 20 different assignments in play by the end of a grading period.

The assessment method described has proven to be effective in elementary, middle level, and high school technology education classes. The performance-based aspect of the portfolio system is designed to remove subjective evaluation. Students, teachers, and parents appreciate the immediate feedback and accuracy of the system.

Many different assignments can be going on at the same time in a typical technology class.

Chapter 2.4

Applying Modular Instruction

Our Roots

The predecessor to technology education, industrial arts, traditionally chose to concentrate on materials such as wood or metal, or a specific subject such as drafting. In the 1970s the growth of technology became more evident to educators, and the funding for programs changed from traditionally supported programs to those that could better fill the needs of students. A new curriculum, based on clusters of related careers evolved to better prepare students for a possible future occupation. The career clusters commonly included:

- Manufacturing
- Communications
- Construction
- Power and Energy

This organization of course content lasted for many years and is still considered important content. Vendors of educational equipment started to provide turnkey programs consisting of a series of topics or modules designed to give students a broader array of experiences in technology education. This new system of modules was seen by many to be the next logical progression from traditional industrial arts to technology education.

Teaching technology education using specific modules of instruction has now become a popular practice at both the middle and high school levels. The system can be an effective means of instruction to insure a common base of information for all students in the program. Having every student rotate through a series of topics for a specific amount of time and testing their comprehension can help to keep students accountable.

Modules commonly offered by vendors might include topics such as:

- Robotics
- Video Production
- Forensic Investigation
- Model Rocket Building
- Bridge Design and Testing
- Drafting
- Animation
- CNC Machining
- Computer Graphics
- Flight Simulation
- Electronics
- Robotics
- Earthquake Simulation
- Car Design

After successfully completing a module, students rotate to another station to begin another topic. Modular instruction can be used effectively as a delivery method for technology education content, and can serve an additional role as an efficient introduction to further study and a possible career exploration. A common question often heard in curriculum development meetings is, “What do we do after the modules?” Model course guides such as the one you are reading and others in the series, offer specific curriculum ideas to help answer this question. Ultimately, technology education teachers should decide on the delivery method they feel comfortable with and that most effectively accommodates the various learning styles of students. The curriculum content can be determined with help from *Standards for Technological Literacy: Content for the Study of Technology* and *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards*.

Multiple Use of Equipment/Facilities

Many of the commercially available modules can also be used in Impacts of Technology or other technology education courses. The equipment dedicated to specific modules can be used again in different capacities when the multiple use concept is applied in courses such as Engineering or Impacts of Technology. Creative scheduling can help to accommodate the use of equipment. Entire module stations might be put on casters to facilitate a more flexible use of the equipment for other classes.

In some schools, a side effect of the move to modular instruction has reduced the ability to use tools and equipment to build student-designed projects. The rush to gut the old woodshop, paint the walls, carpet the floors, and install stations for modules, left many programs without any access to power tools or space to build on student ideas. Making progress in one direction at the expense of flexibility and capability should be a consideration to facility remodeling designs.

The stigma of "smoke and sawdust," often associated with a traditional program, can be dealt with effectively without replacing every power tool with a potted plant to make the room look more like an office setting than a factory. Perhaps a compromise in which the old "shop" can be modernized and changed to a "factory simulation" or "fabrication lab" would accommodate the modular approach while preserving the ability of students to actually build their dreams in addition to simulating them on a computer, an important component unique to technology education. Where else in school will students get the opportunity to actually build something? Designing, simulating, or writing about possible solutions to problems are important components. Technology education is the class in which students should be able to really do something with their ideas. Losing this ability seriously dilutes a student's experience and retards the development of confidence.

Considerations

Delivering content via modular instruction has helped to change the face of technology education. However, using just one form of instruction for an entire curriculum may not provide all students with the freedom to express creativity and practice problem-solving ability. Consider a science teacher deciding that the only teaching method to use is the lecture-test mode. Perhaps the best strategy is to incorporate a variety of methods and build upon previous techniques rather than start entirely over with a single approach. As with most educational changes, there is no one right answer that fits everyone's needs. Teachers should visit a variety of innovative programs to pick-and-choose the methods and activities that best suit their situations.

Administrators interested in implementing sweeping curriculum change in a traditional industrial arts program often see modular instruction as a quick fix to declining enrollment and antiquated facilities. The confusion over the term technology is also a factor that inhibits technology education teachers from making progress toward curriculum change. Many administrators consider technology to mean computers. This confusion between technology education and instructional technology is a real stumbling block in many schools. Generally, technology education teachers were among the first to embrace computers as a new tool to use in an existing curriculum. Unfortunately, it is all too common that the reward for the open-minded technology education teacher using computers has been to have technology education associated solely with computers.

Chapter 2.5

Stimulating Engineering Project Management

Many engineers comment that they are trained to use math and physics to solve difficult problems, but not trained to write reports or organize people. The duties of an engineer often evolve into larger projects that involve the organization of subcontractors, building codes, specifications, and a myriad of engineering specialties. Impacts of Technology can offer students a real experience in preparation for management of any type of complex project. The first problem is getting all students to participate.

A small group of students acting as project managers met before school to coordinate the design and construction of a flight simulator with the help of a local engineer. Students learn about their ability to think while under stress feeling plus or minus 1G in rapid maneuvers. Students answer questions on a timed stress test while doing barrel rolls and spins. A similar test taken at rest gives a comparison score to determine the student's ability to think quickly and accurately while under physical stress.
(Photo by Brad Thode)

Getting Everyone Involved

Cooperative learning is a common teaching method throughout a student's experience in school. The practice is so common that students sometimes fall into a pattern of sitting back and letting others do all the work. This problem is sometimes overlooked by teachers in the hope that the less involved students might work harder next time. Frustration builds as a definite pattern of behavior develops and a student is labeled as someone not to have on a team or in a group.

The non-participating student can sometimes go unnoticed for a time in an action-oriented class such as technology education. Teachers can get involved helping those students who appear to be working hard or try to encourage the student-group leaders to get everyone involved, but the process is rarely smooth. A simple technique can provide a more rewarding experience for all of the students and, with proper planning, guarantee the participation of all students.

Make Everyone an Expert

As assignments become refined and evolve into every teacher's goal of being "kid proof," it becomes obvious that there are standard topics and concepts that must be understood before a problem can be solved or an assignment can be successfully completed. Basic concepts that are crucial to the outcome of a project should be identified by the teacher and added to lesson plans for future reference. Each of these important concepts can be taught to one person in each group. Without each person's specific knowledge, the group will have a difficult time completing the assignment. This practice makes every member of the group a vital participant. Following are some examples of specific concepts that could be used in a group activity. This activity addresses standards for technological literacy and corresponding Benchmarks: *STL* 2, Benchmark EE; *STL* 12, Benchmarks L, P.

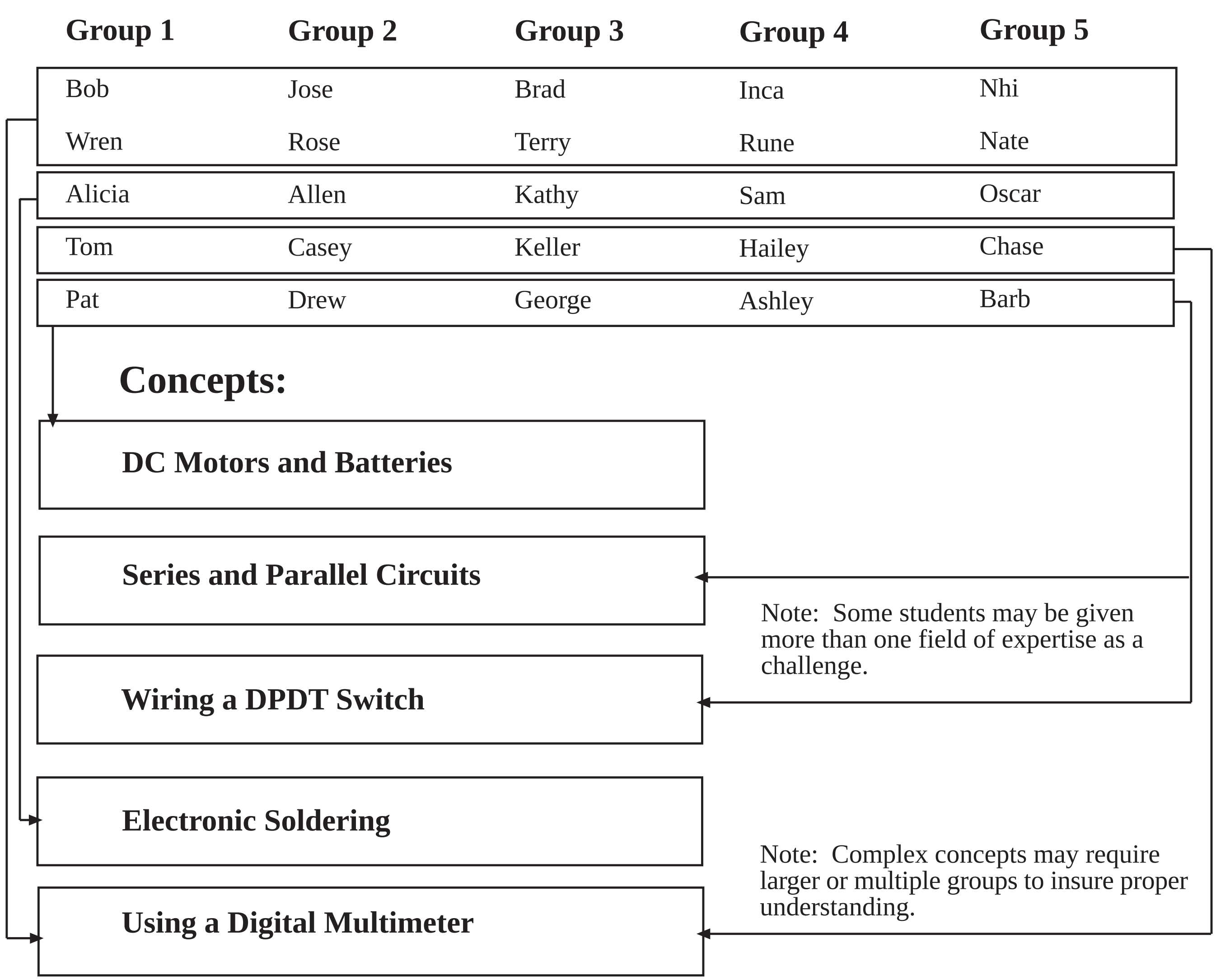
- Reading a micrometer
- Electronic soldering
- Using a digital multimeter
- Plasma cutting
- Wiring a DPDT switch
- Series or parallel circuits
- Using air bearings
- Applying simple machines
- Animating ideas using computer software
- Using appropriate materials
- DC motors and batteries

The process sounds like a teaching nightmare, but with some planning, teachers can create individual experts within each group very quickly. Below is a typical class grouping diagram.

Group Expertise Organization Chart

The students in each concept group are taken aside during a lab time and given specific instruction in individual concepts. Teachers should keep this lesson short and to the point, giving only the *need-to-know* information. Related concepts, or *nice-to-know* ideas, can come later. This lesson may only take a few minutes or as much as one half of the class period.

In practice, after each subgroup of student "experts" have had their individual training, the original groups can meet to discuss strategy for the activity. The chart below represents a problem in which students are challenged to design, build, and test an electric winch system that can raise or lower a specific load. While some group members might have a complete



solution in mind, no one individual has all of the information needed to solve the problem. This process insures the participation of all students and can help build confidence in those students inclined to sit back and watch.

Design Example: Microgravity (µg) Simulator

Students are excited about feeling what it would be like to be in space or walk on the moon. Making this possible became a reality thanks to a technology-related television program that discussed a similar NASA experiment. Students watching the program immediately understood the concept of using bungee cords to replace normal muscle movement in 1G.

A project manager was elected to coordinate the various departments that would be needed to complete this complex design project. Some of the departments included those at right.

Department	Task
• Safety	Quick-release hardware for emergency escape
• Test subject comfort	Backpack frame with climbing harness
• Treadmill control	Automatic kill switch controlled by test subject
• Physiology monitor	Computer heart-rate monitor ear clip
• Testing	10-minute stress test design
• µg Research	Determine gravity on various planets

Individual training began, and department meetings were held to determine new problems and share progress. As the project evolved, the need to accommodate students of all sizes was apparent. A variable tension mechanism with a spring scale was developed to vary the amount of “gravity” pulling the test subject toward the treadmill. This made it possible for students to feel what it might be like to walk on the moon ($1/6^{th}$ G) or Mars ($3/8^{th}$ G), for example.

Quick adjustment of the bungee cord tension was made possible thanks to a student-designed solution based on a system used to tighten tent cords. The safety department specified foam pads under the test subject even though the maximum height was set at 12 inches. Quick release carabiners made escape during a fire drill a quick maneuver. Two student “spotters” were to be assigned to each test subject.

Initial tests were surprising, as students quickly adapted to a bouncing stride when simulating the moon’s gravity. The motion was similar to archive video of Apollo astronauts. Further surprise came as students stood up after the microgravity experience. A lightheaded, weak-kneed feeling was experienced by some students, similar to astronauts returning to 1G after space flight.

Individual department heads were elected and required to make frequent reports to the project manager. Depending on the length of the course, an organizational chart listing each student and his or her title or responsibilities can help with overall organization. Department head meetings held at least once a week will provide feedback to the managers and reveal bottlenecks where additional help, resources, or time might be needed.

Large departments (six or more students) might be divided into smaller divisions with specific tasks assigned. Teachers need to keep a close eye to ensure that all students feel that they are contributing members to the project. Favoritism toward the “popular” or most vocal students requires constant monitoring.

Watch Out for Pitfalls

The leadership role of project manager has pitfalls in the classroom as well as in the workplace. Care must be taken to avoid favoritism, and large projects may require an assistant project manager. Students can be insensitive to the feelings of others and lose track of the human aspect of leading a group while striving for results. Frequent individual and group discussions provide a vent for frustrations that naturally occur. Teachers should remember to encourage all students to assume a leadership position. Technology education is a place where any student can succeed, from the college-bound student council

Microgravity simulation is possible in Earth's 1G environment. This simulator used bungee cords to make gravity adjustable. The entire project was completed with a $200 minigrant from a parent organization.
(Photo by Brad Thode)

member, to the shy kid in the back row with a reading disability.

Project managers can benefit from individual training in scheduling and making timeline charts to predict completion dates or times. Project Evaluation and Review Technique (PERT) charts or other organizational tools could be introduced. An added perk might involve having student managers use PDAs and scheduling or flow chart software. A special desk and possibly release time from other duties provide a feeling of authority as well as responsibility.

The Role of the Teacher

Teachers unfamiliar with being a facilitator may find the situation somewhat unusual. While the teacher assumes the responsibility for the overall success and safety of the class, student managers must feel empowered to make decisions without constantly looking to the teacher for approval. Care should be taken to ensure that student managers feel comfortable in discussing problems with the teacher, but it should be understood that the teacher will not always provide the answer.

Chapter 3

Technology Assessment

Chapter 3

Technology Assessment

Teachers immediately think of assessment as a method of testing students. Technology assessment, however, is a method of testing various technologies. The process is not without controversy. Opinions, pro and con, will be voiced when new ideas are proposed. Students should be reminded that technology is neither always good nor always bad.

Technology, Good or Bad?

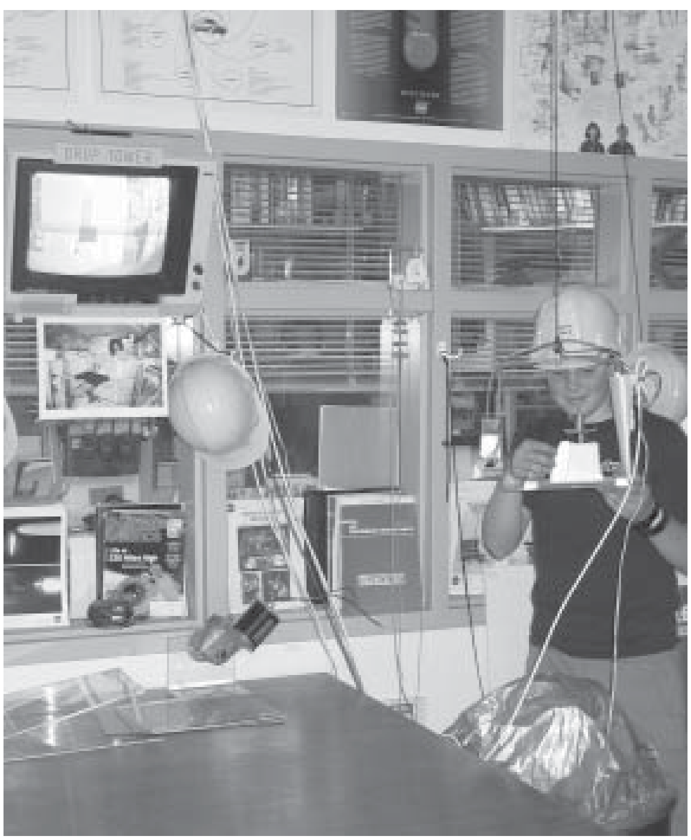
The neutral status of technology can be directly correlated to the goal of making students technologically literate. Through a variety of experiences, students can be taught to examine ideas, inventions, and innovations with regard to their overall benefit to society or the environment. The study of technology education should make students more comfortable in analyzing technologies based on facts and research rather than media hype and personal opinion.

Technology education has a major role in preparing technologically literate citizens capable of making intelligent decisions in the voting booth. Issues that directly influence the future of a democratic society are controlled ultimately by electing knowledgeable leaders. Knowledgeable leaders or self-appointed experts, however, cannot be trusted to make the correct decisions every time. Technology assessment cannot be left up to elected leaders—it is the responsibility of all citizens. Technologically literate voters hold the key to the process, and technology education is perhaps the only place where students will learn this important fact.

We Have Issues

The exponential growth of technology is not likely to come to a screeching halt. As more and more issues related to technology come to the forefront, the level of technological literacy of everyday citizens must keep pace. Issues such as the following are now, or may soon be, decided in the voting booth.

- Human cloning
- World food production
- Genetically engineered babies
- Nuclear power/spent fuel storage
- Human longevity



A high school student prepares a microgravity drop tower experiment. The test chamber will be dropped from a 20-foot high ceiling into the air bag. The experiment will be videotaped using a small video camera on the test chamber. Frame-by-frame playback of the 1.1-second drop video will be analyzed to determine the effects of microgravity. Experiments such as these have led to correlation with language arts classes writing about the benefits and dangers of manned space flight. *(Photo by Brad Thode)*

Democracy is founded on the premise that the population will be educated and literate. With the influence of rapid technological advancements on our society, it would logically follow that technology education would be one of the most important subjects taught in schools. Do administrators and other teachers understand this concept?

Government Regulations

Technology's rapid growth in the past 100 years alone have added to our longevity as well as increasing hazards that previously did not exist. The environmental movement of the 1960s initiated a much greater concern for the impacts of technology on our world. Environmentalists concerned with controlling technology were the driving force behind the National Environmental Policy Act of 1969. This legislation required a previously unheard of document, called an Environmental Impact Statement, for federal actions affecting the environment. During the same time period, additional legislation regulated topics such as the following:

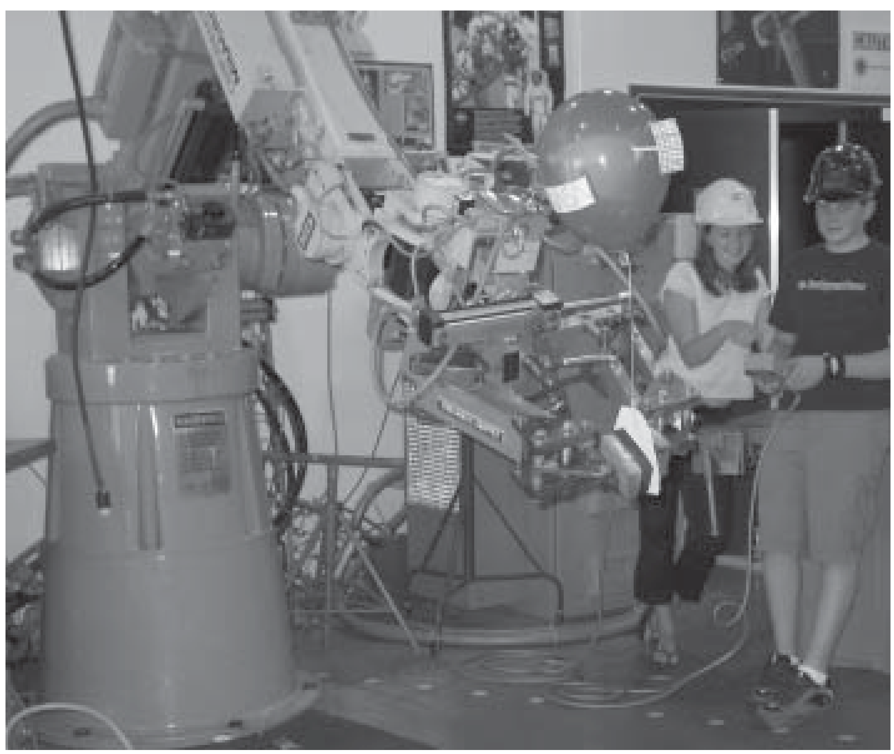
- Nuclear
- Air / water pollution
- Auto safety
- Consumer product safety
- Pesticides
- Occupational health and safety

The Technology Assessment Act of 1972 was designed to consider the possible benefits of new or emerging technologies. While environmentalists are mostly concerned with the control of technology, technology assessment at the federal level focused on the more positive outcomes that new technology often promises. Impacts of Technology is a course of study in which both points of view are equally important, in addition to other factors such as:

- Cultural
- Social
- Economic
- Political
- Historical

Impacts of Technology, Creative Design, and Technology Education

If technology is defined as the ability of humans to combine ingenuity and resources to meet needs and wants of people, then technology assessment is the conscience that polices the possible outcomes of applying technology. This extremely important concept is often glossed over or replaced by quick, unrelated activities designed to be fun without regard to increasing a level of technological literacy. Technology assessment through creative design strives to keep the fun while allowing students' dreams to come to life. Along the way, a growth process helps to develop a deeper appreciation for the possible effects of all this *fun*.



Students operate a hydraulic robot arm to simulate grappling a neutrally buoyant satellite. The robot was donated to the technology education program by a large computer manufacturer. The activity simulates the robot arm used on the space shuttle to grapple satellites for repair on orbit. The neutrally buoyant helium balloon "satellite" floats while students maneuver the robot gripper to a capture position. Along with concepts dealing with microgravity, and robotics, students analyze the application of satellite technology for peaceful and military purposes.
(Photo by Brad Thode)

Chapter 3.1

Analyzing the Fundamentals of Technology Assessment

Technology assessment involves thinking about the possible consequences of actions. What will happen to the flow of a river if a dam is built? How will the change in seat cushioning material in passenger airplanes affect safety? How will the pigments in paint affect the environment in 50 years? Decisions that may seem obviously proper at the time may one day drastically affect thousands of people, creating unhealthy, unsafe, or even potentially fatal conditions. The importance of technology assessment cannot be understated; however, the topic is very controversial.

The topic was considered important enough to rate government agency status in the Office of Technology Assessment (OTA). Given the impossible task of predicting which technologies should be encouraged and which should be discouraged or forbidden by law, Congress abolished the OTA in 1995.

Consider the everyday design and problem-solving activities of an engineer. Solutions to meet given specifications might be obvious. Special considerations may be given to safety and cost of the project, but there are many other implications. In our multicultural society, even the best intentions may be offensive, inappropriate, or unsafe. While solving all of the technical aspects of a job, engineers must also consider many factors such as the following:

- Social
- Cultural
- Economic
- Environmental
- Aesthetic
- Ethical

While mastering the strength of materials, complex electronic formulas, and the myriad of composite materials, engineers must also consider the long-range implications of their designs. Who would have imagined that choosing lead oxide as a paint pigment in the 1950s would contribute to lead poisoning of thousands of children and millions of dollars in clean-up expenses? How could anyone predict that the mineral asbestos could be so useful as a high temperature insulator yet end up causing a form of lung cancer?

The complexity of designing new products and systems may seem so overwhelming that progress would be almost impossible. The fact is that awareness and increased knowledge of technology can greatly improve the chance of avoiding additional problems in the future. Technology educators can play a role in this increased awareness and Impacts of Technology is a logical platform for its instruction.

Future Implications of Today's Technology

Technology assessment provides a process that can be used to help predict the implications of new technologies or the innovative use of existing technologies. Students can quickly understand the concept through simple assignments in which they are asked to predict the impacts of various products or systems. A chart can be used to outline the initial effects, intermediate effects, long-term effects, and overall technological impact of new inventions or innovations.

Tech Activity: Thinking About Technology Assessment

Having students discuss the possible impacts of various technologies can start a process of thinking about possible implications and impacts that can carry through in every practical reasoning application (see Chapter 2.1, Applying All Subjects Through Systematic Problem Solving). The chart on page 51 can be duplicated as needed to provide a structure for brainstorming the effects of technology. This activity addresses standards for technological literacy and corresponding Benchmarks: *STL* 13, Benchmarks J, K, L, M.

Logical Solutions May Lead to Unforeseen Problems

When compact discs started to compete with long playing (LP) records, no one could deny the improved quality of the sound and the convenience of a smaller storage medium. Given the problem of possible shoplifting and the standard size of display racks for long playing albums in existing music stores, engineers were faced with the challenge of designing a package for the new compact discs. The original design consisted of a cardboard box that was twice the size of the CD to make the new product visible in display racks built for LP records. Concern that a smaller package might make the product too easy to conceal, thus creating a shoplifting problem, was also a factor.

The CD soon outsold LP records, and the product's acceptance was assured, but customers wondered why they were forced to purchase such a large package for a small product. All the cardboard and shrink-wrap plastic seamed like a waste—and it was. The solution evolved into re-designed display racks for CDs and reusable plastic carriers with a magnetic antitheft device. Detectors placed at the exits of the store would prevent shoplifting, and landfills would be spared thousands of discarded packages.

Now that CDs have become a standard for both music and computer data, what are some possible implications for the future?

Invention or Innovation	Initial Effect	Intermediate Effect	Long-Term Effect	Technological Impact

Technology Assessment Starting Point Activity

Using the chart format provided below, assign students the task of assessing the technology related to the following concepts:

- Loud music
  What effect might very loud speakers have on hearing?
- Internet music
  How might downloading music change the industry?
- Used CDs
  How will used CDs affect landfills, water / air quality?

What Students See in the Movies vs. Reality

Misconceptions are rampant in the halls and classrooms. Students are often surprised, for example that it is not possible for the Space Shuttle to go to the Moon. They are further frustrated by the fact that the rocket that made the Apollo mission possible, the Saturn V, only exists in a few museums today. Complete bewilderment about the workings of government sets in when students realize that millions of dollars were spent in the destruction of the tools and plans used to build a rocket so powerful that it could have taken astronauts to Mars as well.

When asked why astronauts "float" in space, for example, many students (and adults) answer that it is because there is no gravity in space. In fact, if one thinks about what holds the Moon in orbit, that answer just doesn't make sense. Spacecraft and astronauts in low Earth orbit are traveling at 17,500 miles per hour. Satellites, the Shuttle, the International Space Station (as well as any occupants) are, in fact, constantly falling while moving at just the right velocity to continue falling around the Earth while in orbit. Yes, there is still gravity in orbit. Otherwise, how could a Shuttle land?

Rumors of parents squelching the sale of "hoverboards," skateboards without wheels seen in movies about the future, are often present in classrooms. Students are open to believing all kinds of "technohype" that detracts greatly from the goal of producing a technologically literate citizenry.

Internet research on NASA's Web site provided students with facts about conditions on Mars. This information was used to design, build, and test a Mars Rover Impacts of Technology project.
(Photo by Brad Thode)

Invention or Innovation	Initial Effect	Intermediate Effect	Long-Term Effects	Technological Impact

Invention or Innovation	Initial Effect	Intermediate Effect	Long-Term Effect	Technological Impact or Recommendation

Subject: What effect might very loud speakers have on hearing?

Invention or Innovation	Initial Effect	Intermediate Effect	Long-Term Effect	Technological Impact or Recommendation
Very loud speakers in cars, at dances, or at home.				

Subject: How will used CDs affect landfills, water/air quality?

Invention or Innovation	Initial Effect	Intermediate Effect	Long-Term Effect	Technological Impact or Recommendation
How will used CDs affect landfills, water/air quality? What happens to CDs if they burn? How long will they take to decompose?				

Invention or Innovation	Initial Effect	Intermediate Effect	Long-Term Effect	Technological Impact
Technology Education	Pro: Renewed teacher/student excitement and enthusiasm. Increased funding for facility renovation and updating of equipment Con: Traditional teacher frustration. University level curriculum upheaval, administrator confusion between technology education and educational technology.	Pro: Development of high tech concepts/activities, career information, computer technology, and modular delivery systems. Increased business and industry support. Development of content standards. Con: Multiple University level department closings. Funding for educational technology development, not technology education. Traditional programs holdouts feel alienated.	Pro: Development of high tech concepts/activities, career information, computer technology, and modular delivery systems. Increased business and industry support. Con: Decreased professional involvement. Reduced vendor innovation/participation.	Pro: Increased technological literacy of general population. Greater career awareness and preparedness. Modified general education expectations. Con: Somewhat reduced awareness of traditional materials and processes. Complete separation and technology education programs.

Developing Student Abilities to Assess the Impact of Products and Systems

Technology education teachers understand the fact that students retain more information when given the opportunity to apply their knowledge to real situations. Developing the ability to assess the impact of technology comes with practice and application. The following activity provides teachers with a tool to instantly get students thinking about technology assessment.

Getting accustomed to thinking about the effects of technology can be an interesting mind game for students and an appropriate correlation between technology education and history classes. The discussion categories used here are based on the technology content standards as found in *Standards for Technological Literacy: Content for the Study of Technology*.

In each of the scenarios presented, students should work in small groups to discuss the implication of the topic. Each group will act as the former Office of Technology Assessment. Members of the group may choose to concentrate on a few specific technological considerations but should participate in all discussions, as ideas spawned from brainstorming might spark new thoughts. Internet searches may be used to obtain background material. See Appendix C, Instructional Resources, for background reading and additional resources dealing with each scenario.

This activity should be set up to provide time for research and presentation preparation. After each group completes discussion, research, and organization, a brief panel discussion of their findings and conclusions should be presented to the entire class. Time for class input and discussion should be allowed in order to provide the widest possible experience. Correlation with a history or social studies class further enhances the activity and gives students a broader understanding.

One of the most frustrating parts of being a teacher is repeatedly listening to the same information from students who are not motivated to delve deeper into a topic and find new insights or details. One method of preventing this is to videotape each presentation to show the next class. The first assignment for a new group is to watch the previous tape dealing with the same topic. The assignment is to find additional information or different ideas than those presented by the previous group. This technique can be used in many activities to give students an idea of what is expected without providing all the answers.

Technology Assessment Activities

Eleven different scenarios are provided to accommodate large classes. Depending on class size, students should be divided into groups of approximately four members. A blank form is offered for teachers or students to provide their own scenarios. Reproduce enough of each scenario to provide a copy for each group member. Students should brainstorm each scenario and write a brief *pro* and/or *con* comment under each technological consideration.

- Would our world be different if Native Americans had conquered Europe instead of Europeans taking over the Americas? Starting from the time of Columbus' "discovery" of the New World in 1492, describe the technological considerations and impacts that may have influenced our society today. Give special consideration to changes in food production and house construction.

- AUVs (Autonomous Underwater Vehicles) are being used to explore previously inaccessible oil and natural gas fields on the ocean floor. What might happen to the oil industry, foreign oil dependence, and Middle Eastern politics if an environmentally safe method using robots could be perfected to extract vast amounts of energy? How might the economy be affected?

- Paper has been used as a medium for writing information for thousands of years.

Today, digital pens can read handwriting and display it as typed text on a computer. Digital paper is being perfected so that any image can be displayed or changed as the user requires. A blank book of electronic paper could be changed into any book. Consider the implications of future pens and paper.

- The old saying, "no pain, no gain" might not be able to be used when talking about the future of exercise. Medical research has discovered an enzyme that may modify human muscles without exercise. Such a magic pill might sound strange, but even NASA could benefit if astronauts could avoid muscle loss on long space flights. How could such a fitness pill change society?

- There are approximately 6000 different languages spoken in the entire world. New Guinea has a population of only about a million people, but accounts for around 1000 of the total number of very different languages spoken (each as different as Chinese from English). How would our society be different if over 1000 completely different languages existed in our country?

- What if genetic engineering could modify mosquitoes in such a way that their bites would spread *vaccines* instead of *diseases*? How would infectious diseases such as AIDS, West Nile fever, smallpox, black plaque, malaria, or SARS be different today and throughout history? What effect would this innovation have on products such as window screens, insect repellant, etc.?

- In 1957, a small group of dedicated U.S. scientists designed a very large (4000 ton) spaceship that would be powered by a series of nuclear bomb explosions. Called Project Orion, the scientists projected that a large group of people could have been sent to Mars by 1965 and to Saturn by 1970. How might history have changed if huge rockets (135 feet in diameter) were real?

- NASA, ESA (European Space Agency), and countries such as France, Japan, and Italy are involved with sending robotic sensors and survey satellites to Mars. A manned mission is proposed before 2020. What might happen if robotic probes discover the presence of underground life on Mars? What effect might this have on the possibility of finding other life in the universe?

- Nanotechnology is the ability to work at the molecular level, moving individual atoms to build new structures and machines. Billions of dollars are being invested in research to use nanotechnology to build such things are microscopic "nanobots," or very small robots that could be injected into a person to find and destroy such things as cancer cells or viruses. How else could they be used?

- Ubiquitous means very common. Ubiquitous computing, or *ubicomp*, is a technology that uses low cost silicon chips to sense data and send it to a receiver. Ubicomp windows, for example could sense sunlight and activate shades or air conditioning in a home. Packages could "tell" microwaves how to cook, or show when to discard food. How else might *ubicomp* be used?

- Just 50 years ago, computers took up the space of an entire room. The laptop has shrunk the size of a computer to the size of a book. New models are so small that they are called wearable computers. Using wireless technology to access the Internet, wearable computers use a head-mounted display and a hand-held optical mouse. How could "pocket" computers affect society?

Evaluation

Evaluation of the activity can be based on the rubric on the following page.

TECHNOLOGY ASSESSMENT RESEARCH / PRESENTATION RUBRIC

DIRECTIONS: Put the name of the group member being evaluated at the bottom of the paper. Do not put your name on the paper. Evaluate each member of your group and total the points, considering the following categories:

CATEGORY	OUTSTANDING (25)	ACCOMPLISHED (20)	DEVELOPING (15)	STARTING (10)	POINTS
GROUP INTERACTION	Group member took a leading role in all discussions. Extra effort was made to insure the success of the group. All opinions were valued.	Group member took an active interest in all discussions.	Group member took part in most discussions.	Group member took part in some discussions.	
RESEARCH	Group member took a leading role in all research efforts. Extra effort was made to find additional information and assist others in the group.	Group member found detailed information on assigned topics.	Group member found some information on assigned topics.	Group member looked for information on assigned topics.	
PREPARATION	Group member organized the efforts of the entire group. Encouraged members to do the best possible job.	Group member worked hard to organize their assigned topic.	Group member organized his/her assigned part.	Group member got organized with the help of others.	
PRESENTATION	Group member willingly presented the findings of the entire group and encouraged others to participate.	Group member presented the topic assigned in an effective manner.	Group member was able to support the findings of the group.	Group member was present but did not participate in the presentation.	
	GROUP MEMBER NAME:			**TOTAL:**	

IMPACTS OF TECHNOLOGY – ASSESSMENT WORKSHEET

Group Leader NAME: ______________________

Group Member NAMES: ______________________

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Scenario
What would happen if:

Would our world be different if Native Americans had conquered Europe instead of Europeans taking over the Americas? Starting from the time of Columbus' "discovery" of the New World in 1492, describe the technological considerations and impacts that may have influenced our society today. Give special consideration to changes in food production and house construction.

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CULTURAL			
SOCIAL			
ECONOMIC			
POLITICAL			
ENVIRONMENTAL			
HISTORICAL			
MEDICAL			
AGRICULTURAL			
BIOTECHNOLOGY			
ENERGY & POWER			
INFORMATION & COMMUNICATION			
TRANSPORTATION			
MANUFACTURING			
CONSTRUCTION			

IMPACTS OF TECHNOLOGY – ASSESSMENT WORKSHEET

Group Leader NAME: ______________________

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Scenario
What would happen if:

AUVs (Autonomous Underwater Vehicles) are being used to explore previously inaccessible oil and natural gas fields on the ocean floor. What might happen to the oil industry, foreign oil dependence, and Middle Eastern politics if an environmentally safe method using robots could be perfected to extract vast amounts of energy? How might the economy be affected?

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Scenario
What would happen if:

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Scenario
What would happen if:

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Scenario
What would happen if:

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Chapter 4

Creative Design Activity Ideas and Assessment Strategies

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Creative Design Activity Ideas and Assessment Strategies

One difficulty some teachers have when starting an Impacts of Technology class is giving up some of the total decision-making process to students. The other roadblock to a successful Impacts of Technology class is the lack of definite plans for projects. Traditional teacher training devised the old "plan your work and work your plan" adage. Impacts of Technology requires teachers to learn along with students, something that some teachers have a hard time accomplishing. The traditional role of teacher as the "sage on the stage" assumes that the teacher will have all of the answers. With the rapid growth of technology, it is humanly impossible for any one person to know everything.

Learning along with students can be a challenge at first, but it is an effective teaching strategy that guarantees student-teacher involvement. Guiding students toward a solution and giving them credit for unique ideas builds confidence and provides a real-world application for other subjects.

The activity examples in this section are actual Impacts of Technology projects from middle level and high school technology education classes. Detailed drawings are purposely not provided because students need to go through the process of discovery themselves. Otherwise, they are back to following plans designed by someone else.

Creative Design Ideas

Perhaps the most stressful point in establishing an Impacts of Technology program is coming up with an idea or topic. The best solution to this problem is to let students brainstorm until they can agree on a few possible topics. Lacking immediate student buy-in, teachers may need to provide a potential list of possibilities. Here are some ideas for starting the creative juices flowing:

Aerospace
- Space station
- Space shuttle simulator
- Microgravity simulator
- Build an observatory
- Build a planetarium (inflatable structure)
- Flight simulation

Remote Control
- Robotics
- Mars Rover simulation
- R/C Airplanes, cars, blimps (with video transmitter)

Biotechnology / Agriculture
- Hydroponics
- Isolation of DNA
- Clone plants

Cleanroom
- Produce fiber optics
- Simulate integrated circuit (IC) automation
- Produce a silicon transistor
- Industrial materials handling (glovebox)

Invention / Innovation
- Design and build a working robot
- Improved packaging
- Ergonomics / anthropometry / human factors engineering

Video / Audio
- Design and build a video or audio studio
- Student radio / TV station
- 3-D graphics / animation
- Audio CD production (student bands)

Forensics
- Fingerprinting
- Crime scene investigation
- Fiber analysis
- Bone trauma (using chicken bones)

Lasers
- Light shows
- Holography

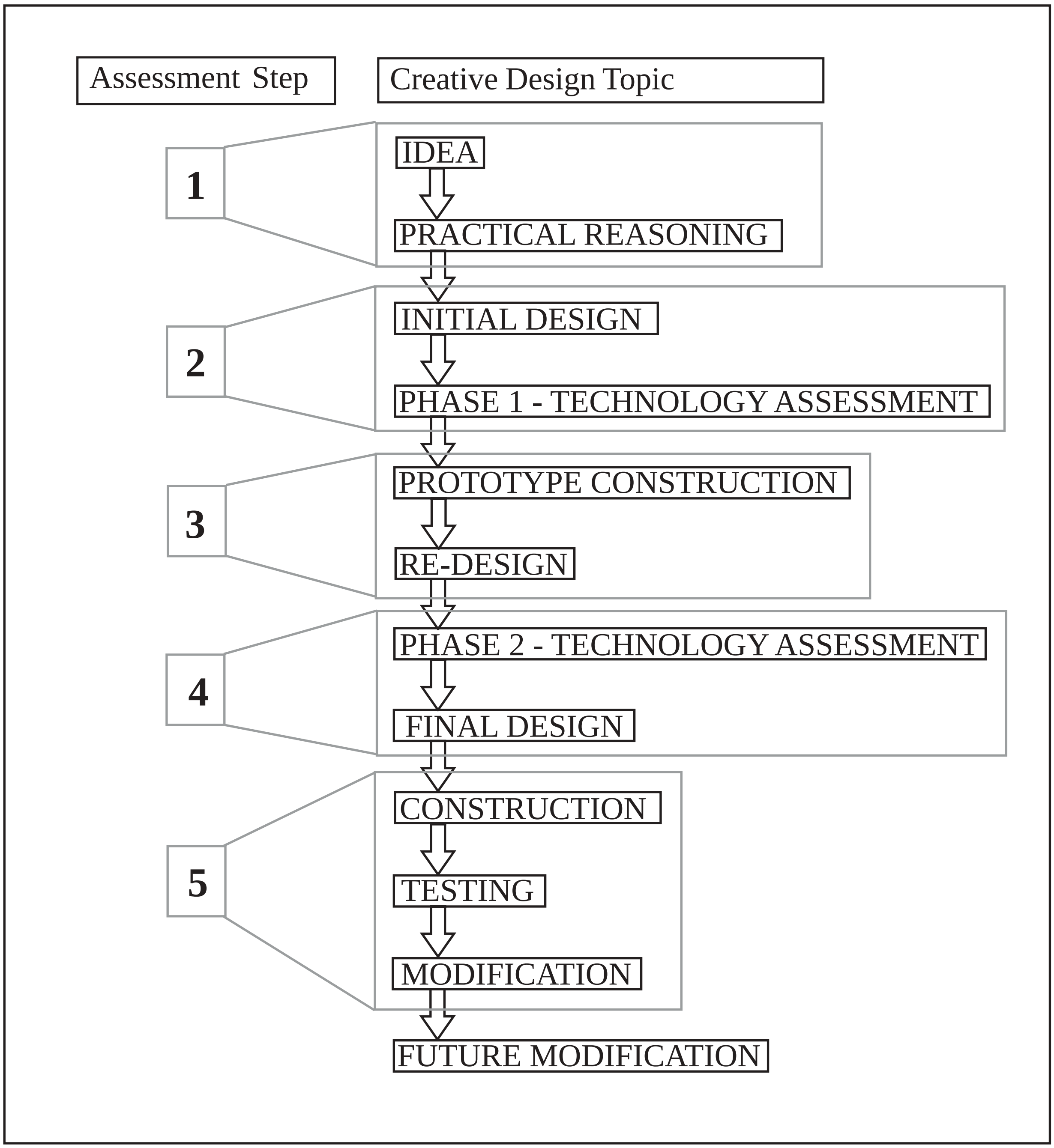
Future Transportation
- High mileage vehicles
- Electric cars
- Human-powered vehicles
- Alternative energy

Impacts of Technology Assessment

Assessment in any class must be an ongoing process. Students deserve to know their status, and parents can be frustrated if poor performance goes unnoticed, resulting in a bad grade. The steps in the creative design process can be conveniently divided into five assessment points for a course lasting a quarter, trimester, or semester. Year-long courses require assessment at each step of the process. The chart below illustrates the assessment points for a typical Impacts of Technology course.

Assessment Step 1

The first assessment period is an important time to set the expectations for the Impacts of Technology course. Starting out with a very lenient attitude can make it difficult for a teacher to increase requirements later in the course. Establishing a creative design environment and following the problem-solving steps is a critical part of the class.



Assessment Step 2

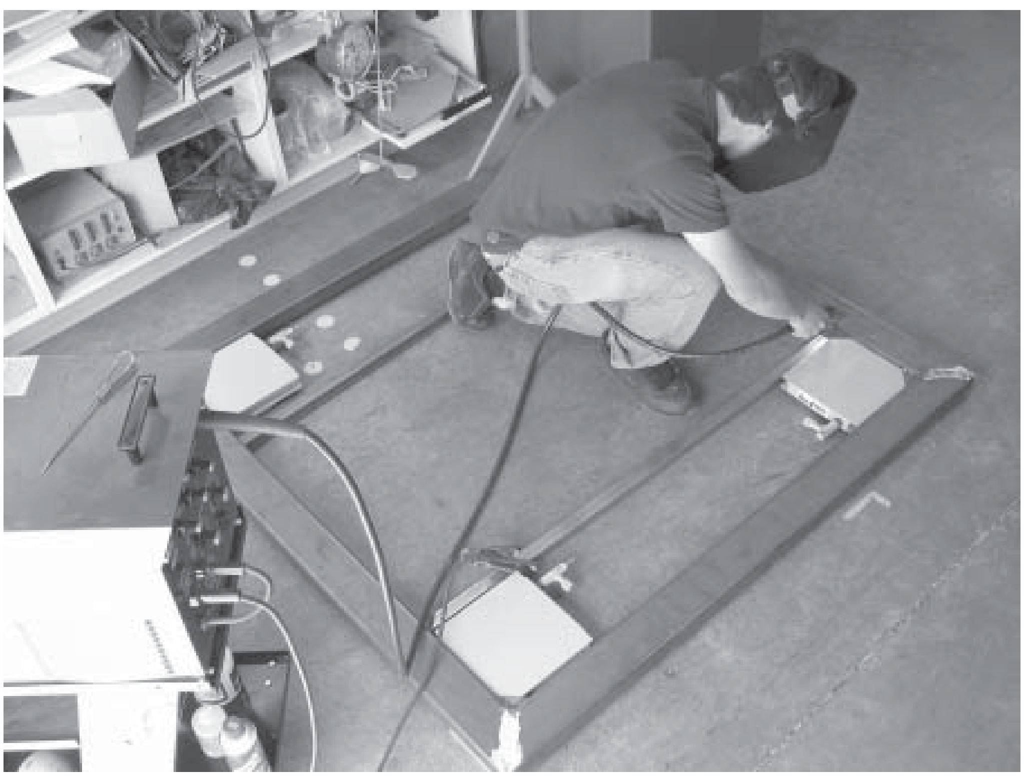
After getting off to a good start, the momentum of the class can be increased through careful and subtle encouragement or suggested changes in using classroom time. This is the time to encourage those students who have been hesitant to participate. Let them know that their ideas are needed and respected. Keep a close eye on students who dominate the class activities without regard for the involvement of others.

Assessment Step 3

Safety is of extreme importance in any technology education class. This evaluation might serve as an encouragement for most students to continue to follow the safety rules. However, for those students who refuse to follow specific safety rules or to use hand or power tools appropriately, it might serve as documentation for discipline procedures. All students must prove the ability to be safe in the technology lab. It is strongly suggested that a predetermined plan of action be followed to deal with safety issues. One possible series of steps to deal with safety violations might include the following steps:

> Any student who does not follow safety rules or use tools safely will immediately be removed from the technology lab area until the following steps are taken:
>
> 1. Teacher / student discussion of violation
> 2. Review of written safety rules and tests
> 3. Parent notification and conference
> 4. Notification of administration / counselor
> 5. Disciplinary action as needed
> 6. Possible removal from technology education class

The construction of the prototype can set the tone for the overall quality of the finished product or project. Duct tape, for example, is a poor substitute for appropriate fastening methods. Students trying to hurry the process may try to cut corners, thinking that their methods were accepted in other classes. Quality craft work can still live in a technology education class.



The construction phase is often the most exciting part of creative design. *(Photo by Brad Thode.)*

Assessment Step 4

Going through the process of redesign and a second look at possible technology assessment impacts might seem like the same old assignment already accomplished. Without this important second look, there is a chance that a very small change, which might be overlooked, could make an enormous difference. For example, in 1942, organic chemists manipulated just a few chlorine molecules to develop the chemical that became known as DDT. Experts thought they had discovered the perfect insecticide. Widespread use of DDT saved an estimated 50 million lives from the ravages of malaria and other insect-borne diseases. Perhaps further investigation might have revealed the environmental impact of DDT.

Assessment Step 5

The final construction, testing, and modification of the Impacts of Technology project is the most exciting part of the entire process. Students love to see progress and are often impatient with the preliminary process of research and planning. This phase can be the most satisfying for those students who felt hesitant to participate in classroom discussions. Teachers should make sure that all students have an equal opportunity to participate in the construction of the project. The construction activity helps to build pride and ownership in the project, and possibly in school overall. The legacy of the completed project will live on long after students have graduated.

Interview Assessment

The rubrics provided for each of the five steps can be used more effectively if an individual interview between teacher and student is a standard part of the assessment process. The interview should be conducted in confidence. Other students in the class should be otherwise occupied until called. This might be an appropriate time to show a technology-related video or other sit-down activity. Requiring a set of factual notes based on the video and including the notes as a grade can help to keep students on task while waiting for an interview.

The rubric can serve as a point of discussion during the interview, but other concerns may surface at this time. Possible interview discussion topics might include:

- Group interaction frustrations
- Safety issues / requirements
- Attitude adjustment suggestions
- Motivation level
- Cooperation (or lack of…)
- General concerns (student or teacher)
- Praise

The interview provides an ideal time for praising appropriate behavior as well as inappropriate behavioral modification. Letting students know that, during a particular class, it was observed that they demonstrated safe work habits or a helpful attitude can go a long way toward bolstering confidence.

Confusion can be avoided if both the teacher and student take time to sign and initial the completed rubric form. A blank for initials is provided after the names on the rubric form. If a parent has a question about when the form was completed, a documented date and period can help clear any misunderstandings. Disagreements over points can be negotiated if the student offers documentation of completion. Copies of the completed rubric should be kept in the student's portfolio to show parents during conferences (see Chapter 2.3, Portfolio Assessment). Examples of Assessment Rubrics can be found in Appendix D.

Designing Technological Products

The key to involving students in the designing of products is to make the experience as real as possible and to put students in charge (with appropriate guidance). Over 30 years ago, industrial arts changed from a woods, metals, drafting content to manufacturing, construction, power/energy, and communications. The manufacturing curriculum became a popular method for updating a traditional program. In many cases however, the change was in name only.

Teachers sometimes devised plans for a “product” that students would mass-produce. The *product* in this case was really another *project* that students had to build in a revamped shop class. While the experience might have included the forming of a corporation, advertising, and sale of a product, the designing of the product was often considered the teacher’s domain, not the students’.

Prototype design, development, and testing often took a back seat during the manufacturing curriculum due to time constraints and teacher-control issues. Impacts of Technology can offer students a place and time to delve deeper into the design of technological products.

Designing Products in Technology Education

Quite often, even the smallest community has a local inventor or business interested in new product designs or innovation. In large cities, it may be harder to find the right person to contact and cooperate in a creative design activity. In both instances, an advisory committee can be of help. Asking local business leaders to serve as advisors to a technology education program can open many opportunities. Forward-thinking CEOs, company presidents, or business managers have a real stake in quality education to create their future workforce. While these executive types may not be directly involved in product development, they can often provide access to a network of people who would be more than willing to help if asked by a supervisor. Lacking local involvement should not deter the design process, as students have the best idea of what types of products would be of interest to other students.

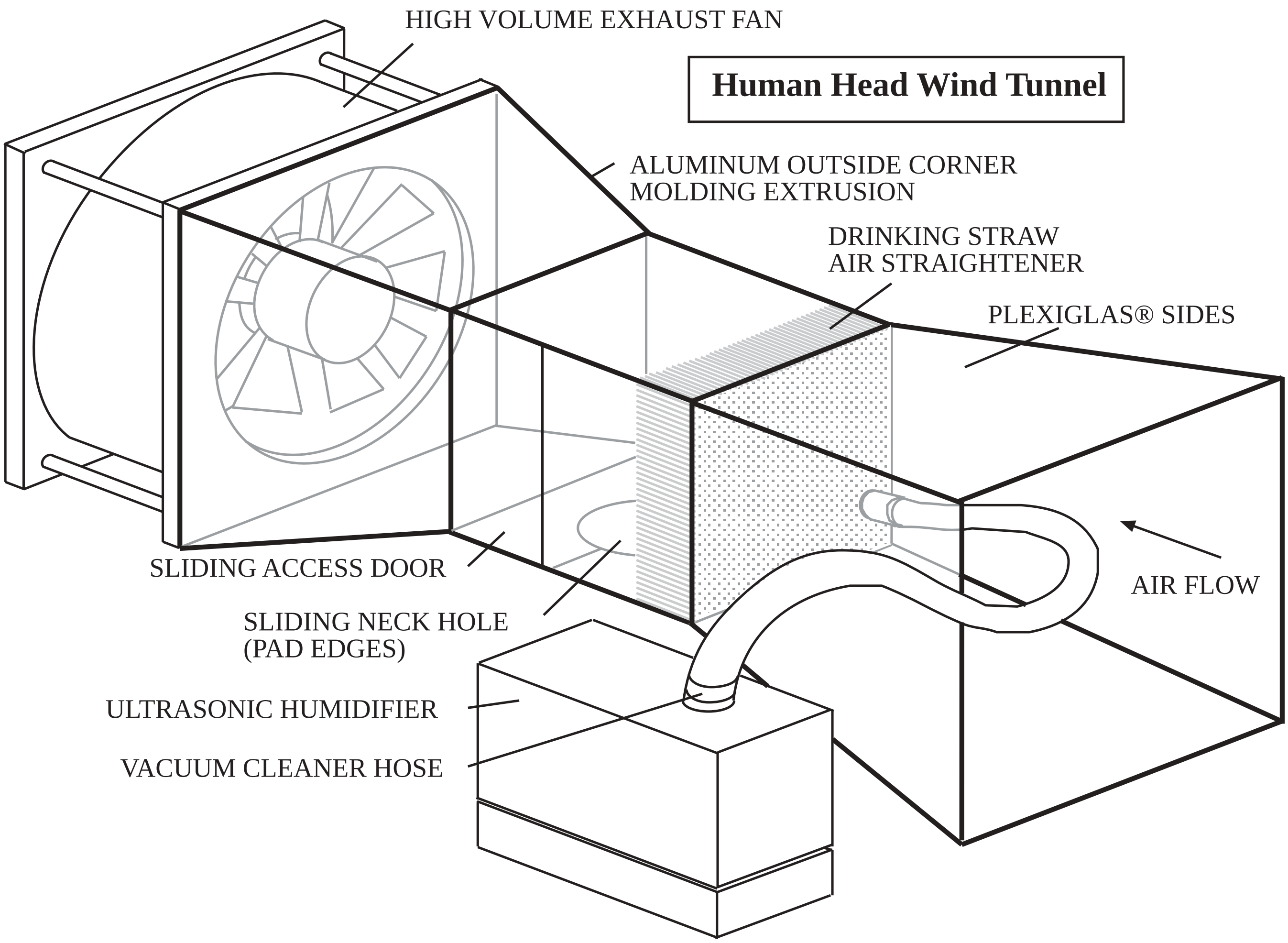
A common frustration voiced by students given a design assignment involves the stringent limitations set by the teacher. Giving students a design challenge and then limiting them to specific shapes of cutting boards or trivets would be similar to telling a young Thomas Edison to design any kind of candle to produce light. In fact, the design experience may not even involve making a product. Rather, it might entail building a testing device that could be used in the development of future products.

Classroom Example: The Human Head Wind Tunnel

In a small resort area in central Idaho, the ski industry and tourism in general provides the largest employment base. Innovation in the sporting goods business involves industrial designers, technical illustrators, mechanical engineers, and a myriad of business professionals. This product development example provided an opportunity for students (and the teacher) to experience the entire product design process from start to finish.

Once a technology education program becomes established in a community, the word gets out that the school is interested in working with the community. The pride and ownership instilled in former students comes full circle as those students graduate from college or gain employment in local businesses. In this example, the “try anything” reputation of the technology education program offered a perfect place for true product development.

During an open house, a parent was amazed at the type of activities going on in a high school technology education program. Further discussion revealed that the parent was involved with the design and manufacture of ski goggles and sunglasses for a nation-wide company with a local head office. It quickly became apparent that a mutually beneficial plan could be



arranged in which students became a part of a new ski goggle design.

Initial meetings with an industrial designer let the Impacts of Technology class see what types of products were already on the market. The idea was to offer goggles designed for younger skiers so they would not need to use oversized goggles made for adults. Students in the class were excited about being involved with the design of a real product (and even more excited when they learned that the company would give every student involved a pair of sunglasses or goggles of their choice).

The process started with the introduction of ergonomics and anthropometry. Students worked with a human factors specialist to compile statistics on head sizes and distance between eyes. The next step required students to research how air flows around objects and how fogging of glasses or goggles might be reduced. The designer suggested we build a wind tunnel to test possible ideas for this new product.

Specifications for the wind tunnel were determined by brainstorming ideas. It was determined that the wind tunnel device should have the following specifications:

- Comfortably accommodate any person's head.
- Provide an adjustable wind speed.
- Afford visibility to video the test for later study.
- Include a non-toxic smoke source to study air movement.

The final design included Plexiglas® sides, donated by a local glass company, and a high volume exhaust fan, donated by the local fire department.

Initial tests proved frustrating and uncomfortable for the test subject as well as the student designers. While various sunglasses and ski goggles could be tested, the results were based on feelings and impressions rather than repeatable experiments. A reliable method of comparing the various shapes and styles of sunglasses and ski goggles was found in a student-suggested solution. An ultrasonic humidifier was used as a non-toxic “smoke” source. The water vapor could be directed toward the test subject using a clean plastic vacuum cleaner hose. In addition to providing a method of seeing the air turbulence during the wind tunnel test, the water vapor was also effective in testing the fogging characteristics of goggles.

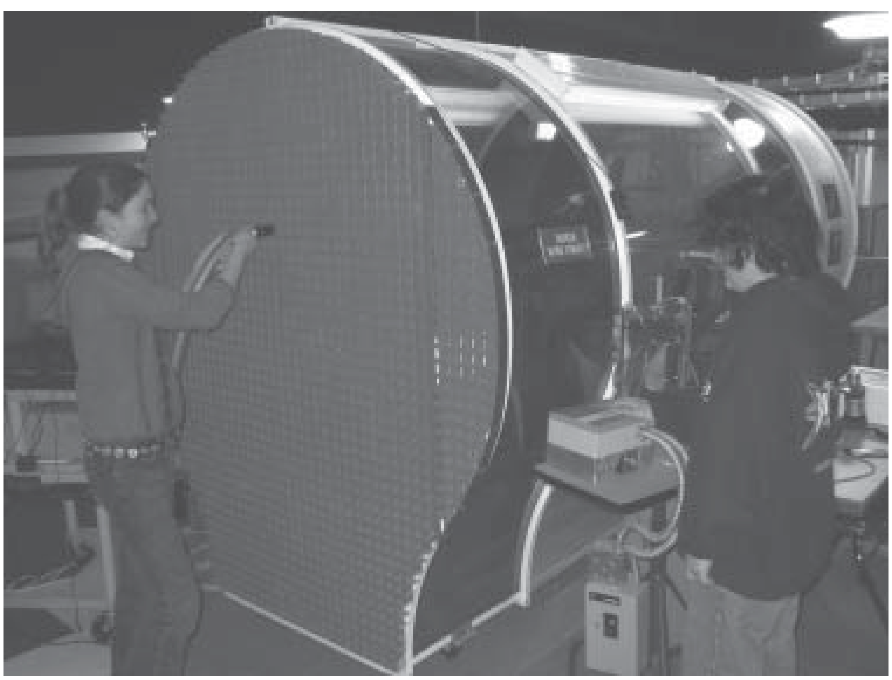
Another problem was noticed after using the water vapor fog test. The design of the wind tunnel provided a reduced test chamber area to increase air speed, but the shape created eddy currents. The air around the test subject’s head was seen to reverse direction near the sides of the test chamber. Even though the fan was used to draw room air through the wind tunnel rather than introduce fan turbulence by blowing air into the tunnel, random air currents existed. Another simple solution was offered during a brainstorming session. The area directly ahead of the test subject was packed with hundreds of drinking straws to straighten the airflow. This laminar flow removed another variable from the tests.

Each student in the Impacts of Technology class served as both test engineer and test subject. Industrial designers made close-up videos of water vapor movement for further analysis. An interesting situation developed when the water vapor was seen to bend around the sides of sunglasses and curl behind the lens at certain wind speeds. Students learned the importance of properly fitting sunglasses to prevent possible problems—from dust while biking, for example.

With anthropometric measurements and tests completed, the process of prototype development was taken over by the goggle company. Impacts of Technology students devised other experiments using the human head wind tunnel and started to design an even larger wind tunnel big enough for students to enter for testing drag forces in biking and alpine skiing.

In a few weeks, students (and the teacher) learned how a high-density polyurethane foam is being used as a medium to create accurate prototypes. The designer showed the class a meticulously shaped foam prototype based on the measurements taken in the class. A detailed CAD drawing illustrated the foam prototype’s dimensions. Last minute changes were made to the working drawing based on student input. The final plans were sent to Germany to have an injection mold created to produce the new product.

Just before the end of the trimester, the designer brought a large, heavy box into the classroom. The injection mold had been machined, and enough of the new ski goggles were made to give one to every student. In a period of 12 weeks, students were able to see a complete product development example. From conception, to research, to prototype design, to modification, to completed product, students had an excellent opportunity to be a part of developing a real product.



The Human Wind Tunnel was designed and built by students to measure the drag force on skiers and bikers.
(Photo by Brad Thode.)

DRAFT

Chapter 4.2

Designing Technological Systems

Standards for Technological Literacy defines *systems* and *processes* as:

- Systems
  A system is a group of interrelated components designed collectively to achieve a desired goal. Systems thinking involves understanding how a whole is expressed in terms of its parts and, conversely, how the parts related to each other and to the whole.

- Processes
  A process is a systematic sequence of actions used to combine resources to produce an output.

The advantage of thinking in terms of systems is in the simplification of complex combinations of sub-systems that create a technological goal. Consider the complex world of engineering, for example. No one individual could be an expert in every field of engineering. Some of the specific engineering fields are listed below.

- Electrical
- Chemical
- Civil
- Aerospace
- Aeronautic
- Computer
- Automotive
- Nuclear

Engineers specialize in a specific field and often further specialize in a very specific area. A nuclear engineer might specialize in fuel rod storage and control for example. Studying systems are similar in that a very complex subject can be better understood if it is broken into smaller parts.

Students can quickly divide a complex problem into systems and subsystems to develop an understanding of a complex machine or process. Systems are a natural part of organized study in many fields. Physicians studying the human body, for example, would understand the workings of all systems before selecting a specialty.

- Digestive
- Nervous
- Skeletal
- Respiratory
- Muscle
- Circulatory
- Reproductive
- Excretory

Studying a complex machine is no different. Understanding an entire machine can be intimidating even to experts, but dividing the whole into systems and subsystems can make the problem manageable. Consider the systems in an automobile, for example:

- Steering
- Braking
- Electrical
- Computer
- Navigation
- Mechanical
- Ignition
- Fuel
- Sound

Systems can be understood using more generic categories that describe most of the components found in any complex machine or system. The systems include:

- Electrical
- Thermal
- Chemical
- Mechanical
- Fluid (Hydraulic / Pneumatic)

The machine dissection activity described in Chapter 2.1, Systematic Problem Solving, can benefit from the same organizational categories.

Systems Design Example

Consider the design challenge of making thin glass filaments that can be used as fiber optics to carry laser light. Middle level and high school technology education students were able to attack this complex challenge by learning about the various systems and subsystems needed to accomplish the goal.

Research

In researching the production of fiber optic cables, the following facts were found:

- The process must take place in a cleanroom to avoid contamination from dust and other impurities.

Students working in a cleanroom environment learn about possible future careers.

- o The cleanroom must have a special positive pressure ventilation system.
- o Cleanrooms require workers to wear special clothing (over-boots, suit or smock, rubber gloves, hood).
- o Workers entering the cleanroom must walk over an adhesive dust mat.
- o Workers must take an "air shower" before entering the cleanroom.

- High temperatures (1500° F) are required to melt the pure glass used to make the fibers.
- Glass fibers must be cooled to room temperature before they can be coiled.
- Care must be taken to avoid handling sharp, broken fibers.
- The speed of the "take-up spool" determines the finished diameter of the fiber.
- Fibers can be tested using a Helium-Neon (HeNe) laser.
- Further experimentation can measure the laser intensity coming through the fiber with a meter.
- Fibers can be tested to determine if they will carry a voice signal using a modulated HeNe laser.

Get Help!

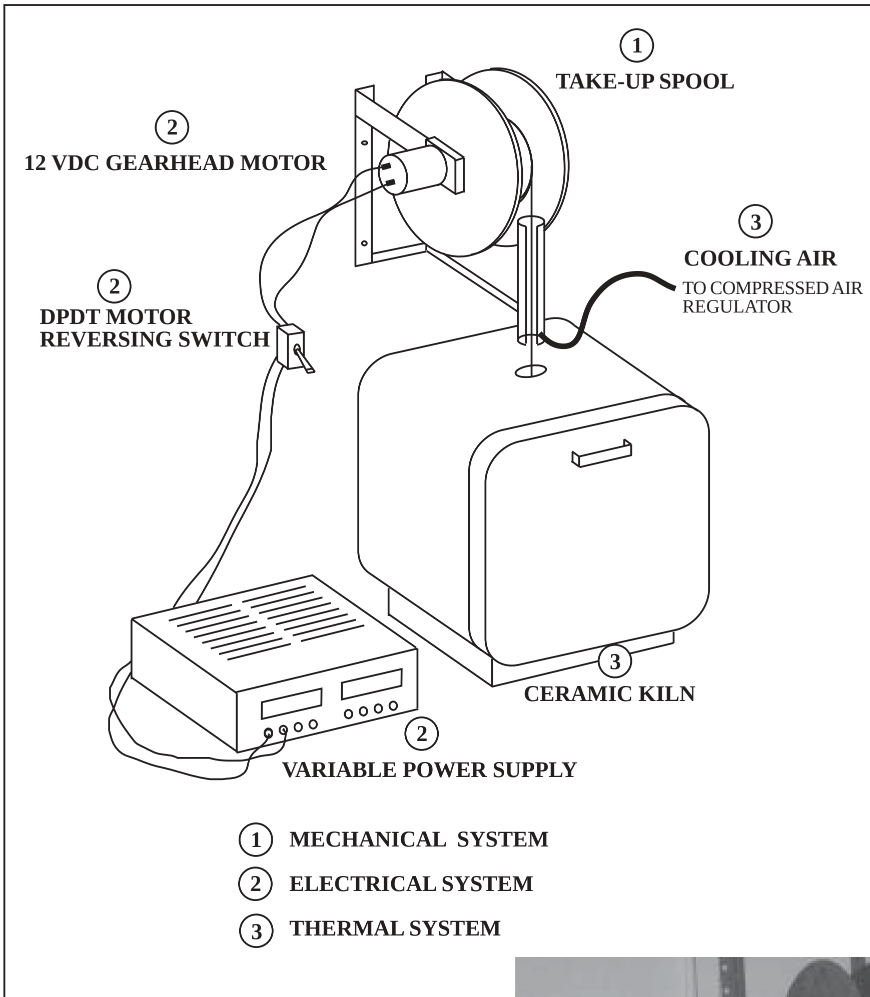
A local engineer was consulted regarding the design of cleanrooms, and it was learned that a few inexpensive modifications to an existing darkroom would create a serviceable clean area for fiber optic production. The darkroom had not been in use since the switch to digital photography. Having students wear cleanroom suits and having them understand some of the procedures associated with working in a cleanroom was an added benefit related to possible future high-tech careers.

Just as engineers need to specialize in a specific field, technology education teachers should not feel they need to know all the answers to every project that students imagine. Bringing in "expert" consultants or researching topics via the Internet can open many new concepts to teachers as well as students. Help is available from many sources such as:

- Parents or relatives of technology education students
- Local or regional engineering firms or businesses
- Local, regional, or state technology education supervisors or administrators
- Professional organizations
- Professional journals / newsletters
- Internet searches
- NASA regional centers or Web site search
- Local service groups (Rotary, Kiwanis, Lions Club, Jaycees, etc.)

Not only can these sources offer expertise, but they often get excited about helping students and offer financial support in the form of grants or donated materials or equipment. Many business and industry leaders would like to help education, but are not sure how to best apply their influence. When approached about a specific

FIBER OPTIC CABLE PRODUCTION SYSTEMS



The apparatus for creating a system to make fiber optic cables is not complicated if broken into sub-systems such as mechanical, thermal, and electrical. Individual groups of students can specialize in one system. Motivated students can be assigned project manager status and assume some of the organizational duties. Students can learn to apply time and other resources in the most efficient manner to achieve their goal.

Facility Modification

Many technology education labs have a space that is underutilized or in need of remodeling. One approach to changing a “shop” into a “lab” is to pick the darkest, dirtiest area to become the newest high-tech facility. The darkroom example discussed could just as easily have been an old dirty finishing room or storage area.

project, most business professionals will either become involved directly, or see to it that the right person is contacted. Press coverage after the project is completed is often a welcome reward for students, teachers, and supporting organizations.

Class Organization

The tasks associated with each system were divided among students in an advanced technology education class. Over a period of two trimesters (24 weeks), students were able to remodel the darkroom into a cleanroom and assemble the apparatus illustrated.

Technology education students use various systems to create fiber optic cables, using an inexpensive ceramic kiln and various custom-made devices.

Chapter 4.3

Designing for the Future

Thinking about the future can be exciting or frightening, depending on your point of view. Students are used to seeing futuristic science fiction movies that can paint a dismal forecast for the effects of technology. The concept that *technology* is neutral, neither good or bad, is an important lesson. The study of the appropriate application of technologies for either good or bad purposes is what technology assessment is all about.

The Impacts of Technology curriculum is an ideal place to emphasize the appropriate use of technology. Students can be encouraged to apply their ideas and knowledge of technology in a positive direction. Technological innovation in the form of weapons and other life-threatening topics would not be appropriate.

Designing for the future has a very big advantage—there are no wrong answers. While no one knows exactly what the future holds, trends in technology and society can help develop realistic predictions. An introductory video of futuristic science and technology topics can help students focus on a topic of interest.

One of the factors that sometimes limits teacher enthusiasm for this type of project is the fact that all of the projects are new and the outcome is unknown. While this can intimidate some instructors, it can also serve as an exciting change of pace for open-minded teachers.

There are some roadblocks that can frustrate the teaching of an Impacts of Technology course. Questions that teachers might ask include:

"How can I purchase supplies for unknown projects?"
"What happens to the project when the course is over?"
"Who is responsible for the completion of the project?

Instructors contemplating the start of an Impacts of Technology course can do some preparation to anticipate the needs of students. Some suggested preparations include:

- Start with a machine dissection activity in which students take apart old machines and equipment (see Chapter 2.2, Classroom and Lab Management.)

- Organize a group of interested teachers. A one- or two-person department can quickly be overcome with student needs. This is a perfect opportunity to approach other teachers to become a part of a team dealing with a theme.

- Gather parent support. Enthusiasm can often overcome a lack of expertise in helping with student projects.

- Contact other technology education teachers. Local, regional, state, and national organizations often have Web-based newsletters or listserve databases that can find other teachers with similar interests.

The future of technology is as unpredictable as it is exciting. Students should be given an opportunity to express a positive outlook through a hands-on experience. Here are two examples of student-driven futuristic projects.

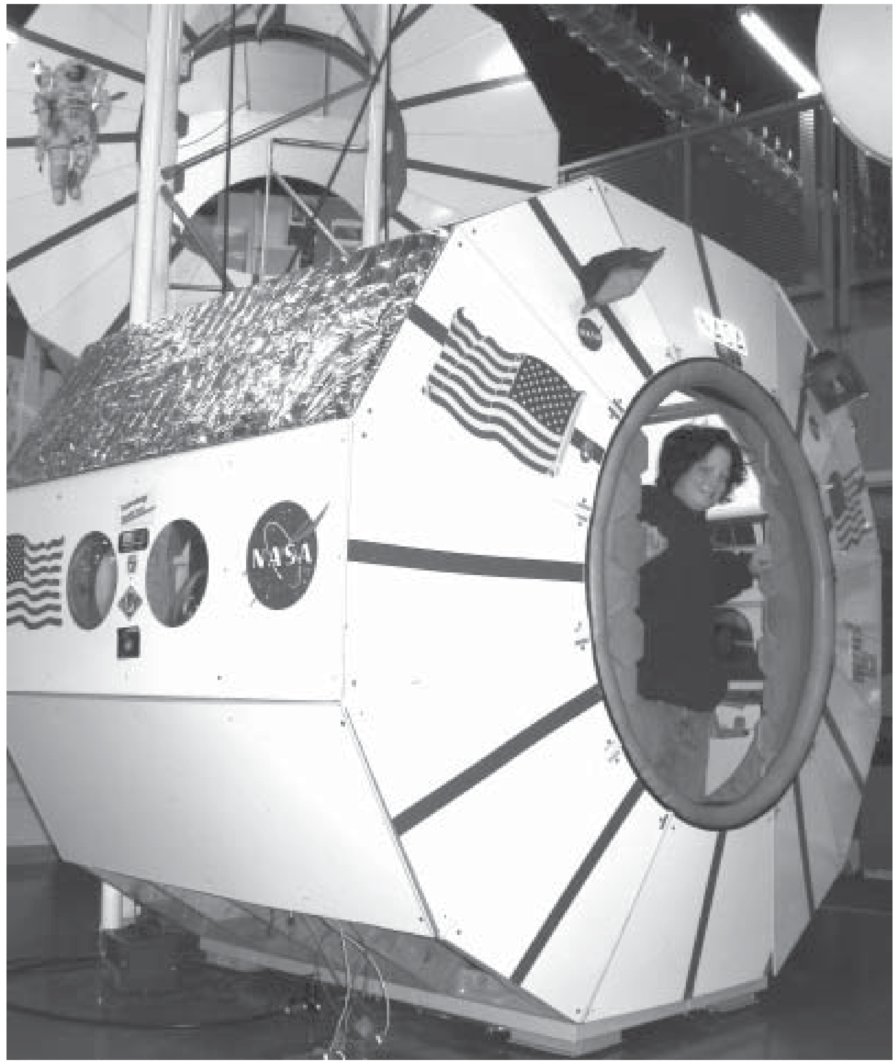
Future Design Challenge: Space Station Simulator

The International Space Station (ISS) is a cooperative venture among 16 nations. A space station simulator can be built in a technology education lab and serve as a multi-subject platform for many students. This "futuristic" project was designed and built by students before the first component of the ISS was launched. Once the structure was built, students in other classes wanted to modify and improve the simulator. As the actual ISS grew, students changed the simulator to better emulate the real thing.

Research indicated that there were many requirements for a space station to ensure safety and provide a platform for countless experiments. Some of the specifications that were considered included the following;

- Removable panels for access to electrical and HVAC systems.

- Large round hatches for easy entrance and exit.
- Low voltage “panic button” to disconnect 120 VAC circuits.
- Video and audio communication with “mission control” located in another room.
- Storage and scientific experiment compartments.



Futuristic creative design can be an exciting project for students at any level. This student-designed space station was built *before* the International Space Station.
(Photo by Brad Thode.)

The construction of the basic frame was a good application of woodworking skills. It was decided to have a dodecahedral (twelve-sided) outside shape and a circular inside shape making curved interior walls. Outside panels were removable and “view ports” were cut into the sides. This part of the project proved to be an ideal project for a transition from a “shop” to a “lab” in that the woodworking skills quickly advanced to more high-tech activities such as computer networking, audio/video communication, and glovebox construction.

Thanks to NASA’s Web site and the myriad examples of printed material regarding the International Space Station, students had a more than adequate amount of research material. Even though the first version of the space station simulator was completed before the ISS, students in other classes were excited to modify the station to include experiment bays similar to the ISS Destiny Module.

A high-tech addition to the completed space station simulator involved making it “float.” Small (nine-inch diameter) air bearings were placed under the four corners of the station, and low pressure air from the lab’s air compressor was easily able to lift the 800+ pound module. Floating on a cushion of air only .02 inches thick provided a frictionless environment that made the simulator very mobile. Future classes plan to develop a maneuvering system to simulate docking the module with the truss.

Mars Rover

Once the space station project was started, students began thinking in terms of space exploration. During the Pathfinder mission, students were excited to remotely control (R/C) 4-wheel drive models, modified to simulate a robotic rover. While this project involved wireless video and challenges to look for signs of “life” on the Mars simulation area, the feel of being there was lacking. Thanks to a small grant from a parent organization, a new component was added in the form of video goggles. Students could wear a heads-up display to monitor the wireless video camera on the Mars Rover. This was close to virtual reality, but some of the advanced students weren’t satisfied.

Brainstorming ideas during lunch one day, someone suggested a Mars Rover that could actually be driven. The idea was contagious and the research began to bring ideas in from many sources. Students decided that the Mars Rover should have the following specifications;

- Control of steering and acceleration from a "joystick."
- All electric operation.
- Space-frame lightweight truss design.
- Easily used by right or left handed people.
- Mechanical and electrical breaking.

One of the first steps was to actively seek help from a local engineering firm. An enthusiastic electrical engineer was found who was willing to work during lunch and after school as needed to keep students on task. Systems were identified and tasks divided among students to speed up the process. In addition to basic materials processing skills, for the first time students had a real need to understand schematic drawings and assemble real electronic controls. Thanks to the engineer's meticulous detail given to routing wires, color-coding, and crimping fittings, the circuits were tested and approved. The end result is very drivable, but students already have plans to add suspension, a roll bar, and a safety cage.

Materials for the Mars rover included steel tubing and conduit. Students were excited to learn how to weld certain parts as needed. Rather than designate a certain time for welding, it was found to be most effective to teach welding when students need to know how. This teachable moment involved stopping the entire class to cover safety and welding fundamentals. While everyone had a chance to practice welding and understand the process, the unit was limited to "need to know" basic information. Students were not given the opportunity to lose track of the overall goal of building a Mars Rover.

The student-designed and built Mars Rover futuristic project provided experience in many systems and application of practical reasoning.
(Photo by Brad Thode.)

Chapter 5

Appendix

Acknowledgments

There are many talented and creative educators in the field of technology education. A special thank you goes out to the following individuals for their commitment to the advancement of technology education and their continuing efforts to go beyond the basics:

Brad Thode, Technology Education Teacher
Wood River Middle School
Hailey, Idaho

Terry Thode, Technology Education Teacher
Hemingway Elementary School
Ketchum, Idaho

Doug Walrath, Technology Education Teacher
Wood River Middle School
Hailey, Idaho

Chip Miller, Technology Education Teacher
Summit High School
Bend, Oregon

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North Carolina:	Tom Shown, State Supervisor, Technology Education Consultant, North Carolina Dept. of Instruction
North Dakota:	Don Fischer, State Supervisor, Technology Education, Department of Career and Technical Education
Tennessee:	Thomas D'Apolito, State Supervisor, Tennessee State Dept. of Education
Utah:	Melvin Robinson, State Supervisor, Technology Education Specialist, Utah State Office of Education
Virginia:	George Willcox, State Supervisor, Technology Education, Virginia Dept. of Education
Wisconsin:	Mark Spoerk, Technology Teacher, Bradley Technology High School, Milwaukee, WI

Special thanks to the following field reviewers who provided valuable feedback in the development of this resource:

Listing of Technology Content Standards in *Standards for Technological Literacy: Content for the Study of Technology (STL)*

The Nature of Technology

Standard 1. Students will develop an understanding of the characteristics and scope of technology.

Grade Level		**Benchmarks:** *In order to comprehend the scope of technology, students should learn that:*
K-2	A.	The natural world and human-made world are different.
	B.	All people use tools and techniques to help them do things.
3-5	C.	Things that are found in nature differ from things that are human-made in how they are produced and used.
	D.	Tools, materials, and skills are used to make things and carry out tasks.
	E.	Creative thinking and economic and cultural influences shape technological development.
6-8	F.	New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.
	G.	The development of technology is a human activity and is the result of individual and collective needs and the ability to be creative.
	H.	Technology is closely linked to creativity, which has resulted in innovation.
	I.	Corporations can often create demand for a product by bringing it onto the market and advertising it.
9-12	J.	The nature and development of technological knowledge and processes are functions of the setting.
	K.	The rate of technological development and diffusion is increasing rapidly.
	L.	Inventions and innovations are the results of specific, goal-directed research.
	M.	Most development of technologies these days is driven by the profit motive and the market.

Standard 2. Students will develop an understanding of the core concepts of technology.

Grade Level		**Benchmarks:** *In order to comprehend the core concepts of technology, students should learn that:*
K-2	A.	Some systems are found in nature, and some are made by humans.
	B.	Systems have parts or components that work together to accomplish a goal.
	C.	Tools are simple objects that help humans complete tasks.
	D.	Different materials are used in making things.
	E.	People plan in order to get things done.
3-5	F.	A subsystem is a system that operates as a part of another system.
	G.	When parts of a system are missing, it may not work as planned.
	H.	Resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time.
	I.	Tools are used to design, make, use, and assess technology.
	J.	Materials have many different properties.
	K.	Tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing.
	L.	Requirements are the limits to designing or making a product or system.
6-8	M.	Technological systems include input, processes, output, and at times, feedback.
	N.	Systems thinking involves considering how every part relates to others.
	O.	An open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback.
	P.	Technological systems can be connected to one another.
	Q.	Malfunctions of any part of a system may affect the function and quality of the system.
	R.	Requirements are the parameters placed on the development of a product or system.
	S.	Trade-off is a decision process recognizing the need for careful compromises among competing factors.
	T.	Different technologies involve different sets of processes.
	U.	Maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its quality.

	V.	Controls are mechanisms or particular steps that people perform using information about the system that causes systems to change.
9-12	W.	Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems.
	X.	Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems.
	Y.	The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.
	Z.	Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.
	AA.	Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.
	BB.	Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.
	CC.	New technologies create new processes.
	DD.	Quality control is a planned process to ensure that a product, service, or system meets established criteria.
	EE.	Management is the process of planning, organizing, and controlling work.
	FF.	Complex systems have many layers of controls and feedback loops to provide information.

Standard 3. Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Grade Level		Benchmarks: *In order to appreciate the relationships among technologies as well as other fields of study, students should learn that:*
K-2	A.	The study of technology uses many of the same ideas and skills as other subjects.
3-5	B.	Technologies are often combined.
	C.	Various relationships exist between technology and other fields of study.
6-8	D.	Technological systems often interact with one another.
	E.	A product, system, or environment developed for one setting may be applied to another setting.
	F.	Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.
9-12	G.	Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.
	H.	Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.
	I.	Technological ideas are sometimes protected through the process of patenting.
	J.	Technological progress promotes the advancement of science and mathematics.

The Nature of Technology

Standard 4. Students will develop an understanding of the cultural, social, economic, and political effects of technology.

Grade Level		Benchmarks: *In order to recognize the changes in society caused by the use of technology, students should learn that:*
K-2	A.	The use of tools and machines can be helpful or harmful.
3-5	B.	When using technology, results can be good or bad.
	C.	The use of technology can have unintended consequences.
6-8	D.	The use of technology affects humans in various ways, including their safety, comfort, choices, and attitudes about technology's development and use.
	E.	Technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences.
	F.	The development and use of technology poses ethical issues.
	G.	Economic, political, and cultural issues are influenced by the development and use of technology.
9-12	H.	Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.
	I.	Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects.
	J.	Ethical considerations are important in the development, selection, and use of technologies.
	K.	The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees.

Standard 5. Students will develop an understanding of the effects of technology on the environment.

Grade Level	**Benchmarks:** *In order to discern the effects of technology on the environment, students should learn that:*	
K-2	A.	Some materials can be reused and/or recycled.
3-5	B.	Waste must be appropriately recycled or disposed of to prevent unnecessary harm to the environment.
	C.	The use of technology affects the environment in good and bad ways.
6-8	D.	The management of waste produced by technological systems is an important societal issue.
	E.	Technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems.
	F.	Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another.
9-12	G.	Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling.
	H.	When new technologies are developed to reduce the use of resources, considerations of trade-offs are important.
	I.	With the aid of technology, various aspects of the environment can be monitored to provide information for decision making.
	J.	The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment.
	K.	Humans devise technologies to reduce the negative consequences of other technologies.
	L.	Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment.

Standard 6. Students will develop an understanding of the role of society in the development and use of technology.

Grade Level	***Benchmarks:*** *In order to realize the impact of society on technology, students should learn that:*	
K-2	A.	Products are made to meet individual needs and wants.
3-5	B.	Because people's needs and wants change, new technologies are developed, and old ones are improved to meet those changes.
	C.	Individual, family, community, and economic concerns may expand or limit the development of technologies.
6-8	D.	Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.
	E.	The use of inventions and innovations has led to changes in society and the creation of new needs and wants.
	F.	Social and cultural priorities and values are reflected in technological devices.
	G.	Meeting societal expectations is the driving force behind the acceptance and use of products and systems.
9-12	H.	Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and values.
	I.	The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures.
	J.	A number of different factors, such as advertising, the strength of the economy, the goals of a company, and the latest fads contribute to shaping the design of and demand for various technologies.

Standard 7. Students will develop an understanding of the influence of technology on history.

Grade Level	**Benchmarks:** *In order to be aware of the history of technology, students should learn that:*	
K-2	A.	The way people live and work has changed throughout history because of technology.
3-5	B.	People have made tools to provide food, to make clothing, and to protect themselves.
6-8	C.	Many inventions and innovations have evolved using slow and methodical processes of tests and refinements.
	D.	The specialization of function has been at the heart of many technological improvements.
	E.	The design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships.
	F.	In the past, an invention or innovation was not usually developed with the knowledge of science.
9-12	G.	Most technological development has been evolutionary, the result of a series of refinements to a basic invention.
	H.	The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials.
	I.	Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.

J. Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how.
K. The Iron Age was defined by the use of iron and steel as the primary materials for tools.
L. The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society.
M. The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology.
N. The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time.
O. The Information Age places emphasis on the processing and exchange of information.

Design

Standard 8. Students will develop an understanding of the attributes of design.

Grade Level	Benchmarks: *In order to realize the attributes of design, students should learn that:*
K-2	A. Everyone can design solutions to a problem.
	B. Design is a creative process.
3-5	C. The design process is a purposeful method of planning practical solutions to problems.
	D. Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.
6-8	E. Design is a creative planning process that leads to useful products and systems.
	F. There is no perfect design.
	G. Requirements for design are made up of criteria and constraints.
9-12	H. The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.
	I. Design problems are seldom presented in a clearly defined form.
	J. The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.
	K. Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.

Standard 9. Students will develop an understanding of engineering design.

Grade Level	Benchmarks: *In order to comprehend engineering design, students should learn that:*
K-2	A. The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.
	B. Expressing ideas to others verbally and through sketches and models is an important part of the design process.
3-5	C. The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results.
	D. When designing an object, it is important to be creative and consider all ideas.
	E. Models are used to communicate and test design ideas and processes.
6-8	F. Design involves a set of steps, which can be performed in different sequences and repeated as needed.
	G. Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.
	H. Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.
9-12	I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.
	J. Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.
	K. A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.
	L. The process of engineering design takes into account a number of factors.

Standard 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Grade Level		**Benchmarks:** *In order to comprehend other problem-solving approaches, students should learn that:*
K-2	A.	Asking questions and making observations helps a person to figure out how things work.
	B.	All products and systems are subject to failure. Many products and systems, however, can be fixed.
3-5	C.	Troubleshooting is a way of finding out why something does not work so that it can be fixed.
	D.	Invention and innovation are creative ways to turn ideas into real things.
	E.	The process of experimentation, which is common in science, can also be used to solve technological problems.
6-8	F.	Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system.
	G.	Invention is a process of turning ideas and imagination into devices and systems. Innovation is the process of modifying an existing product or system to improve it.
	H.	Some technological problems are best solved through experimentation.
9-12	I.	Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.
	J.	Technological problems must be researched before they can be solved.
	K.	Not all problems are technological, and not every problem can be solved using technology.
	L.	Many technological problems require a multidisciplinary approach.

Abilities for a Technological World

Standard 11. Students will develop the abilities to apply the design process.

Grade Level		**Benchmarks:** *As part of learning how to apply design processes, students should be able to:*
K-2	A.	Brainstorm people's needs and wants and pick some problems that can be solved through the design process.
	B.	Build or construct an object using the design process.
	C.	Investigate how things are made and how they can be improved.
3-5	D.	Identify and collect information about everyday problems that can be solved by technology, and generate ideas and requirements for solving a problem.
	E.	The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many.
	F.	Test and evaluate the solutions for the design problem.
	G.	Improve the design solutions.
6-8	H.	Apply a design process to solve problems in and beyond the laboratory-classroom.
	I.	Specify criteria and constraints for the design.
	J.	Make two-dimensional and three-dimensional representations of the designed solution.
	K.	Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed.
	L.	Make a product or system and document the solution.
9-12	M.	Identify the design problem to solve and decide whether or not to address it.
	N.	Identify criteria and constraints and determine how these will affect the design process.
	O.	Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.
	P.	Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.
	Q.	Develop and produce a product or system using a design process.
	R.	Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.

Standard 12. Students will develop the abilities to use and maintain technological products and systems.

Grade Level		**Benchmarks:** *As part of learning how to use and maintain technological products and systems, students should be able to:*
K-2	A.	Discover how things work.
	B.	Use hand tools correctly and safely and be able to name them correctly.
	C.	Recognize and use everyday symbols.
3-5	D.	Follow step-by-step directions to assemble a product.
	E.	Select and safely use tools, products, and systems for specific tasks.
	F.	Use computers to access and organize information.

Grade Level		Benchmarks
	G.	Use common symbols, such as numbers and words, to communicate key ideas.
6-8	H.	Use information provided in manuals, protocols, or by experienced people to see and understand how things work.
	I.	Use tools, materials, and machines safely to diagnose, adjust, and repair systems.
	J.	Use computers and calculators in various applications.
	K.	Operate and maintain systems in order to achieve a given purpose.
9-12	L.	Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.
	M.	Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.
	N.	Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision.
	O.	Operate systems so that they function in the way they were designed.
	P.	Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate.

Standard 13. Students will develop the abilities to assess the impact of products and systems.

Grade Level **Benchmarks:** *As part of learning how to assess the impact of products and systems, students should be able to:*

Grade Level		Benchmarks
K-2	A.	Collect information about everyday products and systems by asking questions.
	B.	Determine if the human use of a product or system creates positive or negative results.
3-5	C.	Compare, contrast, and classify collected information in order to identify patterns.
	D.	Investigate and assess the influence of a specific technology on the individual, family, community, and environment.
	E.	Examine the trade-offs of using a product or system and decide when it could be used.
6-8	F.	Design and use instruments to gather data.
	G.	Use data collected to analyze and interpret trends in order to identify the positive and negative effects of a technology.
	H.	Identify trends and monitor potential consequences of technological development.
	I.	Interpret and evaluate the accuracy of the information obtained and determine if it is useful.
9-12	J.	Collect information and evaluate its quality.
	K.	Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment.
	L.	Use assessment techniques, such as trend analysis and experimentation, to make decisions about the future development of technology.
	M.	Design forecasting techniques to evaluate the results of altering natural systems.

The Designed World

Standard 14. Students will develop an understanding of and be able to select and use medical technologies.

Grade Level **Benchmarks:** *In order to select, use, and understand medical technologies, students should learn that:*

Grade Level		Benchmarks
K-2	A.	Vaccinations protect people from getting certain diseases.
	B.	Medicine helps people who are sick to get better.
	C.	There are many products designed specifically to help people take care of themselves.
3-5	D.	Vaccines are designed to prevent diseases from developing and spreading; medicines are designed to relieve symptoms and stop diseases from developing.
	E.	Technological advances have made it possible to create new devices, to repair or replace certain parts of the body, and to provide a means for mobility.
	F.	Many tools and devices have been designed to help provide clues about health and to provide a safe environment.
6-8	G.	Advances and innovations in medical technologies are used to improve healthcare.
	H.	Sanitation processes used in the disposal of medical products help to protect people from harmful organisms and disease, and shape the ethics of medical safety.
	I.	The vaccines developed for use in immunization require specialized technologies to support environments in which a sufficient amount of vaccines is produced.
	J.	Genetic engineering involves modifying the structure of DNA to produce novel genetic make-ups.
9-12	K.	Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained.
	L.	Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology.
	M.	The sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures.

Standard 15. Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.

Grade Level **Benchmarks:** *In order to select, use, and understand agricultural and related biotechnologies, students should learn that:*

K-2
- A. The use of technologies in agriculture makes it possible for food to be available year round and to conserve resources.
- B. There are many different tools necessary to control and make up the parts of an ecosystem.

3-5
- C. Artificial ecosystems are human-made environments that are designed to function as a unit and are comprised of humans, plants, and animals.
- D. Most agricultural waste can be recycled.
- E. Many processes used in agriculture require different procedures, products, or systems.

6-8
- F. Technological advances in agriculture directly affect the time and number of people required to produce food for a large population.
- G. A wide range of specialized equipment and practices is used to improve the production of food, fiber, fuel, and other useful products and in the care of animals.
- H. Biotechnology applies the principles of biology to create commercial products or processes.
- I. Artificial ecosystems are human-made complexes that replicate some aspects of the natural environment.
- J. The development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food.

9-12
- K. Agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products.
- L. Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering.
- M. Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality.
- N. The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna.

Standard 16. Students will develop an understanding of and be able to select and use energy and power technologies.

Grade Level **Benchmarks:** *In order to select, use, and understand energy and power technologies, students should learn that:*

K-2
- A. Energy comes in many forms.
- B. Energy should not be wasted.

3-5
- C. Energy comes in different forms.
- D. Tools, machines, products, and systems use energy in order to do work.

6-8
- E. Energy is the capacity to do work.
- F. Energy can be used to do work, using many processes.
- G. Power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done.
- H. Power systems are used to drive and provide propulsion to other technological products and systems.
- I. Much of the energy used in our environment is not used efficiently.

9-12
- J. Energy cannot be created nor destroyed; however, it can be converted from one form to another.
- K. Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.
- L. It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings.
- M. Energy resources can be renewable or nonrenewable.
- N. Power systems must have a source of energy, a process, and loads.

Standard 17. Students will develop an understanding of and be able to select and use information and communication technologies.

Grade Level **Benchmarks:** *In order to select, use, and understand information and communication technologies, students should learn that:*

K-2
- A. Information is data that has been organized.
- B. Technology enables people to communicate by sending and receiving information over a distance.
- C. People use symbols when they communicate by technology.

3-5
- D. The processing of information through the use of technology can be used to help humans make decisions and solve problems.
- E. Information can be acquired and sent through a variety of technological sources, including print and electronic media.

F. Communication technology is the transfer of messages among people and/or machines over distances through the use of technology.
G. Letters, characters, icons, and signs are symbols that represent ideas, quantities, elements, and operations.

6-8
H. Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human.
I. Communication systems are made up of a source, encoder, transmitter, receiver, decoder, and destination.
J. The design of a message is influenced by such factors as intended audience, medium, purpose, and the nature of the message.
K. The use of symbols, measurements, and drawings promotes a clear communication by providing a common language to express ideas.

9-12
L. Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information.
M. Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine.
N. Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate.
O. Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.
P. There are many ways to communicate information, such as graphic and electronic means.
Q. Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.

Standard 18. Students will develop an understanding of and be able to select and use transportation technologies.

Grade Level **Benchmarks:** *In order to select, use, and understand transportation technologies, students should learn that:*

K-2
A. A transportation system has many parts that work together to help people travel.
B. Vehicles move people or goods from one place to another in water, air or space, and on land.
C. Transportation vehicles need to be cared for to prolong their use.

3-5
D. The use of transportation allows people and goods to be moved from place to place.
E. A transportation system may lose efficiency or fail if one part is missing or malfunctioning or if a subsystem is not working.

6-8
F. Transporting people and goods involves a combination of individuals and vehicles.
G. Transportation vehicles are made up of subsystems, such as structural propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively.
H. Governmental regulations often influence the design and operation of transportation systems.
I. Processes, such as receiving, holding, storing, loading, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently.

9-12
J. Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.
K. Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another.
L. Transportation services and methods have led to a population that is regularly on the move.
M. The design of intelligent and non-intelligent transportation systems depends on many processes and innovative techniques.

Standard 19. Students will develop an understanding of and be able to select and use manufacturing technologies.

Grade Level **Benchmarks:** *In order to select, use, and understand manufacturing technologies, students should learn that:*

K-2
A. Manufacturing systems produce products in quantity.
B. Manufactured products are designed.

3-5
C. Processing systems convert natural materials into products.
D. Manufacturing processes include designing products, gathering resources, and using tools to separate, form, and combine materials in order to produce products.
E. Manufacturing enterprises exist because of a consumption of goods.

6-8
F. Manufacturing systems use mechanical processes that change the form of materials through the processes of separating, forming, combining, and conditioning them.
G. Manufactured goods may be classified as durable and non-durable.
H. The manufacturing process includes the designing, development, making, and servicing of products and systems.
I. Chemical technologies are used to modify or alter chemical substances.

Grade Level		
	J.	Materials must first be located before they can be extracted from the earth through such processes as harvesting, drilling, and mining.
	K.	Marketing a product involves informing the public about it as well as assisting in its sales and distribution.
9-12	L.	Servicing keeps products in good operating condition.
	M.	Materials have different qualities and may be classified as natural, synthetic, or mixed.
	N.	Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time.
	O.	Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production.
	P.	The interchangeability of parts increases the effectiveness of manufacturing processes.
	Q.	Chemical technologies provide a means for humans to alter or modify materials and to produce chemical products.
	R.	Marketing involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it.

Standard 20. Students will develop an understanding of and be able to select and use construction technologies.

Grade Level **Benchmarks:** *In order to select, use, and understand construction technologies, students should learn that:*

Grade Level		
K-2	A.	People live, work, and go to school in buildings, which are of different types: houses, apartments, office buildings, and schools.
	B.	The type of structure determines how the parts are put together.
3-5	C.	Modern communities are usually planned according to guidelines.
	D.	Structures need to be maintained.
	E.	Many systems are used in buildings.
6-8	F.	The selection of designs for structures is based on factors such as building laws and codes, style, convenience, cost, climate, and function.
	G.	Structures rest on a foundation.
	H.	Some structures are temporary, while others are permanent.
	I.	Buildings generally contain a variety of subsystems.
9-12	J.	Infrastructure is the underlying base or basic framework of a system.
	K.	Structures are constructed using a variety of processes and procedures.
	L.	The design of structures includes a number of requirements.
	M.	Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use.
	N.	Structures can include prefabricated materials.

Instructional Resources

Instructional resources available for teaching technology education are widely available through vendors specializing in the field. Up-to-date materials designed to be exciting to students and easy for teachers to use are provided in pre-packaged kits or easy-to-assemble equipment. Teachers have the choice of instructional delivery methods, ranging from whole-class activities, modular instruction, or a non-linear student directed approach as outlined in this guide.

The choices of materials, texts, references, and equipment are not limited to those listed. Those listed are provided as a courtesy to teachers starting the search for materials. Their inclusion should not be considered an endorsement.

Impacts of Technology is a unique curriculum area of technology education and often requires resources from non-educational sources. Activities and creative design projects, such as Mars Rovers, human-scale wind tunnels, and other student ideas are very specialized. These projects are intended to be designed by students and will not include specific plans or construction details. One of the goals of Impacts of Technology is to give students an opportunity to imagine and engineer solutions to a problem. While following directions to build a project is a skill to be encouraged, the next step is to help students

Many of the materials for this middle school cleanroom glovebox were obtained from a government surplus agency. An open mind and creative imagination is often needed to make use of the wide variety of surplus materials and equipment available.

develop the ability to design projects from scratch.

The unique nature of Impacts of Technology opens a world of resources to both the student and the teacher—in fact it opens the real world beyond the educational realm. Teachers are often surprised to find that the industrial version of a piece of equipment might cost the same, or less, than an educational simulation. Items such as small pneumatic cylinders, for example, are often available through surplus outlets for less than a plastic simulation.

Stretching Budgets

Teachers are encouraged to investigate local, state, or regional government surplus agencies for inexpensive equipment or supplies that can greatly extend a meager school budget. Surplus agencies commonly have specific regulations regarding who can purchase materials and how the materials must be inventoried. Check with local school district personnel or the state technology education specialist for details.

Opening a technology education lab to real-world equipment can also open new hazards. Surplus equipment is not intended for school use, and additional hazards may be a factor before the equipment is put into service. Specifically, surplus equipment such as power tools, lasers, or unique materials can pose a safety hazard. Equipment should be thoroughly checked for electrical and mechanical problems. Laser strength may be beyond the maximum five mw HeNe recommendation for schools. Special caution should also be taken with surplus materials. Aluminum to be re-melted in a foundry furnace, for example, should be checked for magnesium content that could cause a fire.

The Internet as a Resource

The number of online classrooms has grown at a rapid rate, and the Internet has become second nature to most students. Internet searches can produce hundreds of "hits," some of which may not be school-appropriate. Internet filters and appropriate-use agreements kept on file can help to alleviate problems. In all cases, direct teacher supervision is required while students perform Internet research.

Even the most cautious approach to online research can sometimes result in inappropriate site access. Students should be warned of loss of privileges or other disciplinary measures if computer usage is abused.

Reference Books

The following partial list of reference books provides background for many of the activities described in this model course guide. The list is by no means complete and is provided for teachers to use as a starting point in their individual research into the field of Impacts of Technology.

Forensic Technology

Jackson, Steve. (2002). *No Stone Unturned*. New York, NY: Pinnacle BOOKS. Kensington Publishing Corp. ISBN 0-7860-1577-2. www.kensingtonbooks.com.

Forensic investigation is a trend in popular television, but also a growing career path. Teachers interested in background information and real-world examples can find both in *No Stone Unturned.*

Space Exploration / Technology

Dyson, George. (2002). *Project Orion*. New York, NY: Owl Books. Henry Holt & Company. ISBN 0-8050-7284-5. www.henryholt.com.

Project Orion details the history of a proposed nuclear bomb-powered spacecraft. This little-known project from the 1950s was an exercise in problem solving that seemed practical at the time. Imagine 50 top scientists and engineers designing a 4000 ton, 135 foot diameter spacecraft that could have been sent to Mars or Saturn by 1970. The engineering was sound, and government funding provided over a year of development and research.

Harrison, Albert. (2001). *Spacefaring, The Human Dimension*. Berkeley, CA: University of California Press. ISBN 0-520-22453-1. www.uspress.edu.

Learning to live and work in space is not as futuristic as it sounds. This book discusses the hazards that humans will face as they spend more time in microgravity.

NASA, ITEA, Thode & Thode. (2001). *Microgravity: Earth and Space*. Huntsville, AL: Marshall Space Flight Center. EG-2001-01-12-MSFC.

A NASA educator's guide to the study of microgravity through activities geared to technology, science, and mathematics standards.

Design / Engineering

Pugh, Stuart. (1991). *Total Design, Integrated Methods for Successful Product Engineering*. New York, NY: Addison-Wesley Publishing Company. ISBN 0-201-41639-5.

A classic textbook for design and engineering students with detailed examples of the design process used to develop new products.

Petroski, Henry. (1999). *Remaking the World, Adventures in Engineering*. New York, NY: Vintage Books. ISBN 0-375-70024-2.

Interesting background reading on the development, engineering, and construction of engineering projects ranging from the Petronas Towers to the Hoover Dam.

Petroski, Henry. (1994). *Desing Paradigms, Case histories of Error and Judgement in Engineering*. New York, NY: Cambridge University Press. ISBN 0-521-46649-0.

Further reading on the history of engineering covering successes and failures.

Future Technology

Zolli, Andrew, Ed. (2003). *Catalog of Tomorrow*. Indianapolis, IN: Que / TechTV. ISBN 0-7897-2810-9. www.quepublishing.com www.techtv.com.

A fascinating discussion of current and future technologies that could change our society. Complete with Web site references for future reading. Suitable for use in research by middle level and high school students.

Environment

Field, John, Hempel, Gotthilf, & Summerhayes, Colin. (2002). *Oceans 2020, Science, Trends, and The Challenge of Sustainability*. London, England: Island Press. ISBN 1-55963-470-7. www.islandpress.org.

This reference is a compilation of issues most likely to affect the world's oceans in the near future. Based on current research and scientific study, this detailed assessment covers topics such as climate change, fisheries, offshore industry, and shipping.

History / Anthropology / Social Studies

Diamond, Jared. (1999). *Guns, Germs, and Steel*. New York, NY: W. W. Norton & Company. ISBN 0-393-31755-2. www.wwnorton.com.

This book discusses the development of technology and its effects on society. The author discusses the reason behind the rapid development of some parts of the world while others stayed in the stone age.

Amato, Ivan. (1997). *Stuff, The Materials the World is Made Of*. New York, NY: BasicBooks. ISBN 0-465-08328-5. www.harpercollins.com.

A fascinating discussion of how materials historically affected our technology and possibilities for the future.

Technology Education

American Association for the Advancement of Science. (1989). *Science for All Americans: A Project 2061 report on literacy goals in science, mathematics and technology*. New York, NY: Oxford University Press.

International Technology Education Association. (1996). *Technology for All Americans: A rationale and structure for the study of technology*. Reston, VA: Author

International Technology Education Association. (2000, 2002). *Standards for Technological Literacy: Content for the Study of Technology*. Reston, VA: Author.

International Technology Education Association. (2003). *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards*. Reston, VA: Author.

Thode, Brad, & Thode, Terry. (2002). *Technology In Action*. Peoria, IL: Glencoe-McGraw-Hill. ISBN 0-07-822489-6.

Thode, Brad & Thode, Terry. (1994). *Technology*. Peoria, IL: Glencoe/McGraw-Hill. ISBN 0-8273-5098-8.

Thode, Brad & Thode, Terry. (1995). *TV and Radio Technology*. Peoria, IL: Glencoe/ McGraw-Hill. ISBN 0-538-64479-6.

Other Resources

Resources used in Impacts of Technology should not be limited to traditional educational sources. Printed materials and Internet sites are a few of the common starting points for researching possible Impacts of Technology projects, but other sources should be considered. The following list of resources can expand research opportunities:

Television Programming

- Science Channel
- Tech TV
- Extreme Engineering
- Beyond 2000
- Monster Garage

Local Hospital

- Guest presenters are often available to discuss bio-related technologies.

Service Groups

A short presentation of what Impacts of Technology is about can open the way to professional support or provide a source of advisory committee members.

Videotape, DVD, Satellite TV

If local television sources do not provide the educational programming needed for Impacts of Technology research, there are other sources available. The following list includes ideas for obtaining educational videos that might spark project ideas or provide background information:

- Videotape – Many educational programs and documentaries seen on TV are available on tape or DVD. Sources include:
  - o Discovery Channel http://dsc.discovery.com/
  - o History Channel http://historychallen.com
  - o Science Channel http:// science.discovery.com/
  - o BBC – Science www.bbc.co.uk/science/

- Satellite TV – Some satellite providers offer free programming to schools. A receiver and satellite dish must be purchased and some forms completed to qualify, but there are no monthly charges for programming. This opportunity may provide access to educational channels that are not otherwise available.
  - o DIRECTV www.DIRECTV.com – The School Choice Package provides free programming to schools.
  - o Dish Network www.dishnetwork.com/ commercial – A reduced monthly cost program is available to schools.

The Best Research Source – NASA

NASA has an outstanding array of resources for educators. NASA's Web site, www.NASA.gov, is a gateway to an incredible amount of current and historical data. The diversity of NASA's strategic enterprises or departments encompasses a very wide span of topics. The NASA strategic enterprises include the following:

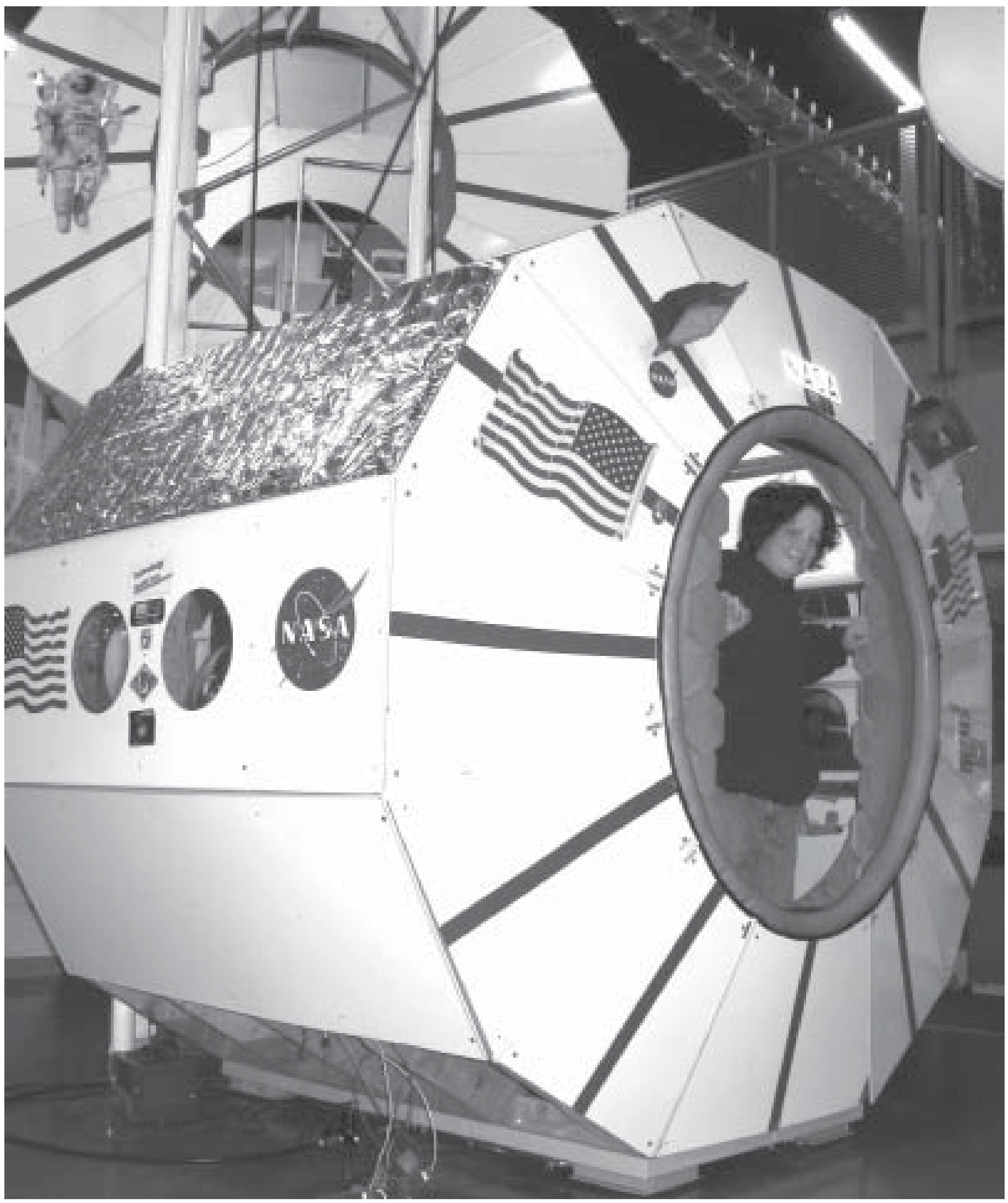
- Aerospace Technology

- Earth Science
- Human Exploration and Development of Space
- Space Science

Many of the possible Impacts of Technology topics that students might be interested in are a part of NASA's research efforts. Teachers and students should do a search of the NASA Web site for most topics as a starting point in gathering information.

NASA offers a wide variety of support for educators through a system of field centers. The centers are located by states in various regions. Consult the NASA Web site to find the center closest to your school.

Another exciting resource for educators is NASA Television (NTV). This excellent television programming source is often available on local cable. If NASA TV is not available locally, it can be obtained via satellite at no charge (see DirecTV listing on the previous page).



NASA provides a wealth of information for Impacts of Technology research. This space station simulator was designed and built by students. The lower module contains experiment racks and a glovebox modeled after the International Space Station (ISS). Guest speakers can be arranged to visit any school. Presentations can include school-wide assemblies or student and teacher workshops. The amount of information available from NASA is staggering. Teachers should narrow their requests to a manageable topic if possible. NASA offers large displays and activity examples at the International Technology Education Association conferences where teacher guides, photos, and posters are available at no charge.

Impacts of Technology Assessment Rubrics

IMPACTS OF TECHNOLOGY ASSESSMENT #1 / Idea and Practical Reasoning (Problem Solving)

TEACHER: ______________________________

STUDENT: ______________________________ **PERIOD:** __________ **DATE:** ______________

CATEGORY	OUTSTANDING (25)	ACCOMPLISHED (20)	DEVELOPING (15)	STARTING (10)	POINTS
CLASS INTERACTION	Student took a leading role in all discussions. Extra effort was made to insure the success of the class. All opinions were valued and encouraged.	Student took an active interest in all discussions and offered ideas during brainstorming sessions.	Student took part in most discussions.	Student took part in some discussions.	
BRAINSTORMING IDEAS	Student took a leading role in all brainstorming sessions. Extra effort was made to encourage others to offer their ideas. Many ideas were offered.	Student was able to offer numerous ideas. Suggestions were offered to benefit the class.	Student offered some ideas.	Student listened but did not offer ideas or suggestions.	
PROBLEM SOLVING	Student organized the efforts of the entire class in solving the selected problem. Prescribed problem solving steps were followed and notes taken. Specified steps in problem solving were memorized, understood, and verbalized.	Student worked to organize the problem-solving process for the benefit of the class. Specific problem-solving steps were understood and verbalized.	Student offered some help in the solution of the problem. Specific steps understood, out of sequence.	Student learned the importance of a problem-solving system.	
				TOTAL:	

IMPACTS OF TECHNOLOGY ASSESSMENT #2 / Initial Design & Phase 1 Technology Assessment

TEACHER: ______________________________

STUDENT: ______________________________ **PERIOD:** __________ **DATE:** ______________

CATEGORY	OUTSTANDING (25)	ACCOMPLISHED (20)	DEVELOPING (15)	STARTING (10)	POINTS
CLASS INTERACTION	Student took a leading role in all discussions. Extra effort was made to insure the success of the class. All opinions were valued and encouraged.	Student took an active interest in all discussions and offered ideas during each class.	Student took part in most discussions and offered some suggestions.	Student took part in some of the discussion, but mostly listened.	
DESIGN	Student took a leading role in all design aspects of the project. Extra effort was made to ensure the accuracy of details. Many ideas were offered and openly discussed.	Student was able to offer important input to the design of the project. Care was taken to ensure accuracy.	Student offered some help in the design process.	Student listened but did not offer ideas or suggestions.	
TECHNOLOGY ASSESSMENT	Student organized the efforts of the class or group in a fair assessment of the technological impacts of the project. Insightful and thoughtful ideas were offered for discussion. An open-minded attitude valued the ideas of others.	Student worked toward the evaluation of the project, helped to document the findings or ideas. Serious discussion was offered and ideas valued.	Student offered some ideas regarding the possible impact of the project.	Student listened but did not offer any ideas or suggestions.	
				TOTAL:	

IMPACTS OF TECHNOLOGY ASSESSMENT #3 / Prototype Construction and Re-design

TEACHER: ______________________________

STUDENT: ______________________________ **PERIOD:** __________ **DATE:** ______________

CATEGORY	OUTSTANDING (25)	ACCOMPLISHED (20)	DEVELOPING (15)	STARTING (10)	POINTS
SAFETY	Student followed all safety rules when using a wide variety of tools. Care was taken to ensure the safety of others. Offered clean-up assistance.	Student followed all safety rules and safely used a variety of tools.	Student followed all safety rules and safely used a limited number of tools.	Student followed all safety rules.	
ATTENTION TO DETAIL AND QUALITY	Student took a leading role in insuring the quality of the project, using proper material selection and construction. Care was taken to avoid wasting materials or time.	Student was able to offer important suggestions in the construction of the project. Care was taken to ensure accuracy.	Student offered some help in the construction of the prototype.	Student watched others build the prototype, offering little help.	
RE-DESIGN PROCESS	Student organized the efforts of the class or group in the re-design or modification of the prototype. Changes were made with an open-minded attitude. Ideas of others were valued and sought.	Student worked to make changes where needed. Re-design discussion was open-minded and fair.	Student offered some help in the design of the project.	Student watched, but did not offer to help in the re-design process.	
				TOTAL:	

IMPACTS OF TECHNOLOGY ASSESSMENT #4 / Phase 2 Technology Assessment and Final Design

TEACHER: ______________________________

STUDENT: ______________________________ **PERIOD:** __________ **DATE:** ______________

CATEGORY	OUTSTANDING (25)	ACCOMPLISHED (20)	DEVELOPING (15)	STARTING (10)	POINTS
GROUP/CLASS INTERACTION	Student offered to help document ideas and provide serious input. Encouraged others to participate.	Student provided important input that set an appropriate example for others.	Student offered some input.	Student watched but did not participate.	
PHASE 2 TECHNOLOGY ASSESSMENT	Student took a leading role in the re-evaluation of the possible impacts after re-design. Offered help to others and kept an open mind to changes required.	Student was able to offer help in the re-evaluation process. A serious attitude prevailed, and the ideas of others were valued	Student offered some help in the re-evaluation of the modified design.	Student watched others but did not offer any suggestions.	
FINAL DESIGN	Student organized the efforts of the class or group in the final design of the project. Changes were made with an open-minded attitude. Provided help in drawing the final plans.	Student worked to make changes where needed to the final design. Helped in producing final plans.	Student offered some help in the final design.	Student watched but did not offer to help in the final design.	
				TOTAL:	

IMPACTS OF TECHNOLOGY ASSESSMENT #5 / Construction, Testing, and Modification

TEACHER: ______________________

STUDENT: ______________________ **PERIOD:** ________ **DATE:** __________

CATEGORY	OUTSTANDING (25)	ACCOMPLISHED (20)	DEVELOPING (15)	STARTING (10)	POINTS
CONSTRUCTION	Student offered to help to build the project with concern for safety, appropriate material/process application, and time management.	Student provided help in the construction of the project while working carefully. Provided attention to details.	Student offered some help in the construction process.	Student watched but did not participate.	
TESTING	Student took a leading role in designing tests that could accurately evaluate the project. Provided organizational skills in documenting test results.	Student was able to offer help in the testing of the final project. A fair and open-minded attitude set a good example.	Student offered some help in the testing of the project.	Student watched others but did not offer any help in the testing process.	
MODIFICATION	Student organized the efforts of the class or group in the modification of the project based on test results. Changes were made without losing sight of the goal to make a quality project.	Student worked to make changes where needed to the final design. Helped in producing final plans.	Student offered some help in the modification process.	Student watched but did not offer to help.	
				TOTAL:	

IMPACTS OF TECHNOLOGY ASSESSMENT RESEARCH / PRESENTATION RUBRIC

DIRECTIONS: Put the name of the group member being evaluated at the bottom of the paper. Do not put your name on the paper. Evaluate each member of your group and total the points, considering the following categories:

CATEGORY	OUTSTANDING (25)	ACCOMPLISHED (20)	DEVELOPING (15)	STARTING (10)	POINTS
GROUP INTERACTION	Group member took a leading role in all discussions. Extra effort was made to insure the success of the group. All opinions were valued.	Group member took an active interest in all discussions.	Group member took part in most discussions.	Group member took part in some discussions.	
RESEARCH	Group member took a leading role in all research efforts. Extra effort was made to find additional information and assist others in the group.	Group member found detailed information on assigned topics.	Group member found some information on assigned topics.	Group member looked for information on assigned topics.	
PREPARATION	Group member organized the efforts of the entire group. Encouraged members to do the best possible job.	Group member worked hard to organize his or her assigned topic.	Group member organized his/her assigned part.	Group member got organized with the help of others.	
PRESENTATION	Group member willingly presented the findings of the entire group and encouraged others to participate.	Group member presented the topic assigned in an effective manner.	Group member was able to support the findings of the group.	Group member was present but did not participate in the presentation.	
	GROUP MEMBER NAME:			**TOTAL:**	

Glossary

Glossary to be added at a later date.